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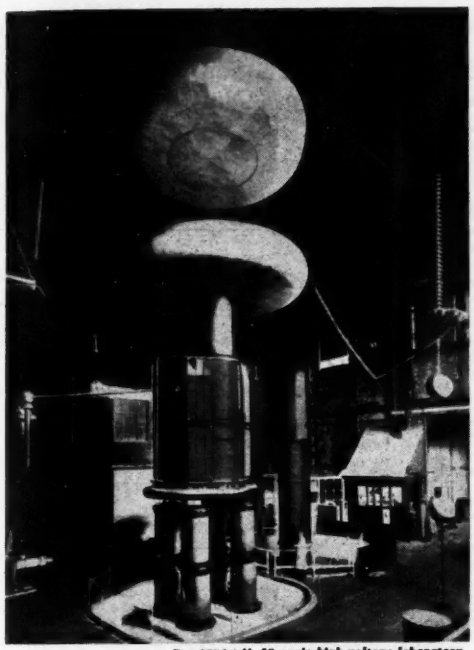

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THE ENGINEER

ESTABLISHED 1856

Vol. 198 No. 5156

NOVEMBER 19, 1954

28, Essex Street, Strand, London, W.C.2.

Telephone : CENtral 6565 Telegrams : Engineer Newspaper, Estrand, London

Published every Friday Registered as a Newspaper

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NOTICE TO READERS

All letters intended for insertion in 'The Engineer or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts: correspondents are therefore requested to keep copies.

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Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

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PUBLIC APPOINTMENTS

UNIVERSITY OF GLASGOW

I.C.I. RESEARCH FELLOWSHIPS

Applications are invited for I.C.I. RESEARCH FELLOWSHIPS in Biochemistry, Chemistry, Engineering, Pharmacology or Physics, to which some appointments may be made during the current academic year. The appointments will date from 1st October, 1955. The salary will depend upon qualifications and experience, but will be within the range £600–£900 per annum, together with F.S.S.U. benefits and family allowances. Applications (eight copies), with a list of publications and names of two referees, should be sent not later than 26th February, 1955, to the undersigned, from whom further particulars may be obtained.

ROBT. T. HUTCHESON,
Secretary of University Court.
E6541

ADMIRALTY

BRITANNIA R.N. COLLEGE, DARTMOUTH

LECTURER OR SENIOR LECTURER

The Civil Service Commissioners invite applications from men for three pensionable posts as LECTURER or SENIOR LECTURER—one in Mathematics, one in Physics and Mechanics, and one in History. Posts to be taken up by April, 1955. Age at least 23 on 1st September, 1954. Normally appointment to the senior grade will not be made under age 30, but it will depend largely on academic qualifications and teaching experience. Candidates must have an appropriate Honours Degree. Teaching experience desirable.

Salary scales (at present under review) : Lecturers, £440–£790 ; Senior Lecturers, £890–£1160. Starting salary above minimum in appropriate cases.

Full particulars and application forms from Secretary, Civil Service Commission, 6, Burlington Gardens, London, W.1, quoting No. 4397/54. Completed forms must be returned by 10th December, 1954. E6582

WIGAN AND DISTRICT MINING AND TECHNICAL COLLEGE

SENIOR LECTURER IN MECHANICAL ENGINEERING

Applications are invited for a post as SENIOR LECTURER IN MECHANICAL ENGINEERING. Duties will commence on 1st January, 1955, or as soon as possible thereafter.

Candidates should hold a good Honours Degree (or equivalent qualification) in Mechanical Engineering, and have practical experience in industry and in teaching. Salary in accordance with the Burnham Technical Scale for Senior Lecturers (£1065–£1215 p.a.).

Further particulars and application form will be sent by the undersigned on receipt of a stamped, addressed, foolscap envelope. Applications should be sent in to reach the undersigned not later than Tuesday, 7th December, 1954. Applications not on the form provided will be disregarded.

E. C. SMITH,
Principal.
11th November, 1954. E6611

COVENTRY TECHNICAL COLLEGE

FULL-TIME TEACHING POSTS

Applications invited for following FULL-TIME TEACHING POSTS, from 1st January, 1955, or later by arrangement. Candidates should be Graduates, or hold good technical qualifications ; previous teaching experience advantageous.

(a) BUILDING DEPARTMENT : Senior Lecturer, experienced in Civil or Structural Engineering.

(b) MECHANICAL ENGINEERING DEPARTMENT.—Assistant Grade B (1 vacancy). Assistants Grade A (3 vacancies).

Applications considered from those experienced in some branch of mechanical, automobile or production engineering. Salaries, 1954 Burnham Technical Scales :—

Senior Lecturers, £1065 by £25 to £1215.
Assistants, Grade B, £525 by £25 to £820.
Assistants, Grade A, £450 by £18 to £725.

Application forms from Director of Education, Council House, Coventry, returnable without delay. E6676

BRITISH RAILWAYS

PADDINGTON

DRAUGHTSMAN

British Railways have a vacancy at Paddington for a DRAUGHTSMAN experienced in design of reinforced and prestressed concrete bridges and structures. Post offers permanency, opportunity for promotion, and carries advantages of superannuation and rail travel privileges.—Apply, giving age, experience, &c., to Civil Engineer's Office, Paddington, London, W.2. E6413

MOTOR INDUSTRY RESEARCH ASSOCIATION

DEPUTY DIRECTOR

Applications are invited for the post of DEPUTY DIRECTOR of the Motor Industry Research Association. Candidates must have high academic qualifications, wide experience in engineering research and, preferably, some administrative ability and a knowledge of the motor industry.

Apply, in writing, giving full details of qualifications and experience, and salary expected, to Director, Motor Industry Research Association, Lindley, Nr. Nuneaton, Warwickshire. E6648

PUBLIC APPOINTMENTS

COUNTY BOROUGH OF DONCASTER

BOROUGH SURVEYOR AND WATER ENGINEER'S DEPARTMENT

APPOINTMENT OF BUILDING WORKS ASSISTANT

Applications are invited for the appointment of a BUILDING WORKS ASSISTANT at a commencing salary of £600, rising to £725 by increments of £25.

Candidates must be experienced in electrical engineering works and be efficient draughtsmen, capable of preparing schemes and estimates for electrical installations. Previous experience in street lighting schemes will be considered an advantage, and candidates should hold suitable electrical engineering qualifications.

Applications, stating age, qualifications and experience, together with the names and addresses of three referees, should reach the Borough Surveyor and Water Engineer, 2, Priory Place, Doncaster, not later than Wednesday, 24th November, 1954.

Candidates must state in their application whether to their knowledge they are related to any member or senior officer of the Council.

The appointment is terminable by one month's notice, and is subject to the provision of the Local Government Superannuation Act, 1937, and to the person appointed passing a medical examination.

H. R. WORMALD,
Town Clerk.
1, Priory Place,
Doncaster. E6561

ADMIRALTY

ADMIRALTY RESEARCH & DEVELOPMENT ESTABLISHMENTS

DRAUGHTSMEN

DRAUGHTSMEN required in Admiralty Research and Development Establishments in London (Teddington area), Bournemouth and Weymouth, with experience in any of the following classes of equipment ; light to medium electrical, electro-mechanical, precision mechanical and electronic.

Candidates must be British subjects, aged 21 years or over, with at least three years' practical workshop training besides drawing-office experience, and have O.N.C. or equivalent.

Appointments unestablished, but opportunities will occur to compete for established posts and for promotion.

Starting pay (London rate) £420 per annum (age 21), £580 (age 28) rising to £670, slightly less in the provinces.

Apply, stating age, training, experience and qualifications, to Admiralty (C.E. II, Room 92), Empire Hotel, Bath. E6583

FOREIGN OFFICE

MINISTRY OF ECONOMICS, IRAQ

GRAIN SILO EXPERT

The Foreign Office invites applications for a post as GRAIN SILO EXPERT under the Ministry of Economics, Iraq.

Duties will be to advise the Iraq Grain Board in negotiations with consulting engineers and contractors for the construction of grain silos ; to supervise the administration and operation of silos, and to help in determining government policy on the storing, cleaning and purification of grain. Should be a qualified Civil or Mechanical Engineer, and must be an expert in the construction, maintenance and operation of silos.

Salary 3600 Iraqi Dinars p.a. (1 D.I. equals £1). A government house (furnished) is available at a reasonable rental, but the post will involve a good deal of travelling within Iraq. Initial contract for two or three years, by mutual agreement.

For further details and application forms write, Ministry of Labour and National Service, A.S.12 Almack House, King Street, S.W.1, quoting A.12/ME/574/IRQ. E6638

CORPORATION OF NOTTINGHAM

WATER DEPARTMENT

CIVIL ENGINEERING ASSISTANT

Applications are invited from engineering graduates and other persons with appropriate qualifications and experience for this permanent pensionable APPOINTMENT. Salary, Grade A.P.T. IV of the National Scale, viz., £580 by £15 to £625. On the 1st January, 1955, the scale will become £600 by £20 to £640. A higher maximum salary may be payable, depending upon qualifications and experience.

Applications, giving the names of two referees, should be sent to the Engineer and General Manager, Water Department, Castle Boulevard, Nottingham, not later than the 6th December.

T. J. OWEN,
Town Clerk.
Guildhall,
Nottingham. E6624

LONDON COUNTY COUNCIL

HANDICRAFT MASTERS

Applications invited for appointment to Council's service as HANDICRAFT MASTERS (Woodwork and/or Metalwork). Vacancies in various districts. Candidates should be qualified teachers or eligible for temporary recognition by Ministry of Education. Burnham (London) scale salary.—Apply at once on form EO/TS 40, obtainable from (please send s.a.e., fscp.) and returnable to Education Officer (EO/TS 4), County Hall, S.E.1. (1504.) E6619

PUBLIC APPOINTMENTS

CORPORATION OF NOTTINGHAM

WATER DEPARTMENT

MECHANICAL ENGINEERING ASSISTANT

Applications are invited for this permanent, pensionable APPOINTMENT at a salary in accordance with Grade A.P.T. VIII of the National Scale, viz., £785 by £25 to £860. On the 1st January, 1955, the scale will become £840 by £30 to £900. Candidates should be not more than 45 years of age, should possess an Engineering Degree and/or be Corporate Members of the Institution of Mechanical Engineers, and should preferably have had electrical and diesel engine experience. The person appointed will be expected to take charge, under the Engineer and General Manager, of the maintenance of the Department's steam, electrical and diesel pumping stations and a small workshop, also to assist in the design and installation of new pumping equipment.

Applications, giving the names of two referees, should be addressed to the Engineer and General Manager, Water Department, Castle Boulevard, Nottingham, not later than the 6th December.

T. J. OWEN,
Town Clerk.
Guildhall,
Nottingham. E6625

WEST MIDLANDS GAS BOARD

WARWICKSHIRE DIVISION

MECHANICAL AND ELECTRICAL ENGINEER—FOLESHILL GASWORKS COVENTRY

Applications are invited from suitably qualified persons for the above post.

Candidates should have had extensive practical experience of the installation and maintenance of mechanical and electrical plant and equipment. Experience of gasworks practice would be an advantage.

Accommodation will be available at a reasonable rental.

The commencing salary will not be less than £1000 per annum.

The post is pensionable and the successful candidate may be required to pass a medical examination.

Applications, stating age, qualifications and experience, together with the names of two referees, should be addressed to the Industrial Relations Officer, West Midlands Gas Board, 6, Augustus Road, Edgbaston, Birmingham, 15, as soon as possible.

F. H. CURETON,
Secretary to the Board.
E6630

CITY OF SHEFFIELD

WATERWORKS DEPARTMENT

APPOINTMENT OF TECHNICAL ASSISTANT

Applications are invited for the above APPOINTMENT on the permanent staff of the Waterworks General Manager and Engineer (J. Noel Wood, M.Inst.C.E.).

Applicants for the post (at present A.P.T. Grade V, £620–£670) must be chartered civil engineers with waterworks experience.

The post is superannuable and the successful applicant will be required to pass a medical examination.

Applications, stating age, education and training, qualifications, present and past appointments (with dates), and quoting the names of two referees, should reach the undersigned not later than 1st December, 1954.

JOHN HEYS,
Town Clerk.
Town Hall,
Sheffield, 1. E6626

MINISTRY OF WORKS

STRUCTURAL ENGINEERING DRAUGHTSMEN

STRUCTURAL ENGINEERING DRAUGHTSMEN required in London and various Regional Offices.

London salaries £420 (at age 21), to £670 per annum. Starting pay according to age, qualifications and experience. Rates in the provinces slightly lower.

Applicants should be experienced in the design and/or detailing of either reinforced concrete or structural steelwork. The work is varied and not confined to standard schemes. Prospects of promotion and establishment.

State age, nationality and full details of training and experience to WG10/S6 (F), Ministry of Works, Abell House, John Islip Street, London, S.W.1. E5388

COUNTY BOROUGH OF READING

WATER DEPARTMENT

APPOINTMENT OF JUNIOR ENGINEERING ASSISTANT

Applications are invited for the above appointment. Salary A.P.T. Grades II-III (£520–£595), according to qualifications and experience. National Joint Council conditions apply. Appointment subject to (a) passing of a medical examination for superannuation purposes, and (b) determination on one month's notice.

Applications, stating age, qualifications and experience, with copies of recent testimonials and names of two referees, should be sent to the Water Engineer and Manager, 16/20, The Forbury, Reading, by 9th December, 1954. E6410

PUBLIC APPOINTMENTS

THE UNITED KINGDOM ATO ENERGY AUTHORITY

ALDERMASTON, BERKS

SCIENTIFIC OFFICERS

The United Kingdom Atomic Energy Au Aldermaston, Berks, requires SCIE OFFICERS as follows :—

Post 1 (109/WGE/25) : PHYSICIST ANICAL ENGINEER, to undertake research on the mechanical effects of stresses to atomic weapons. Research experience in of mechanics or general physics, although ma tial, would be advantageous. Applicants possess a First or Second Class Honours D Physics or equivalent qualifications.

Post 2 (251/WGE/25) : PHYSICIST or M LURGIST, to carry out fundamental and research on reactive inorganic compounds. mum qualification is First or Second Class H Degree in Physics or Metallurgy and prefera be given to applicants with research experi either (1) crystallography, (2) hot press sintering phenomena, (3) growth of polyc aggregates from melts, or (4) solid state phy salary scale is £445–£815 per annum. Starting is assessed according to age, qualifications an rience. Houses available within a reasonable for married officers who live outside the E ment's transport facilities.—Application fo Senior Recruitment Officer, A.W.R.E., Alder Berks. Quote appropriate reference.

NATIONAL COAL BOARD

PRODUCTION DEPARTMENT ENGINEERING DRAWING-OFF

DESIGNER-DRAUGHTSMAN

National Coal Board invite applicatio superannuable appointment of DESI DRAUGHTSMAN in Production De Engineering Drawing-Office at London quarters. Salary according to qualificat experience in the inclusive range £622-£ annum. Candidates must be experienced design of mechanical equipment, preferably ground mining machinery, and they must be carry through design work from the projec manufacturing stages. Experience in the d hydraulic equipment would be an adva Higher National Certificate or equivalent tion is desirable.

Write, giving full particulars (in chron order) of age, education, qualifications and e (with dates), to National Coal Board, Establ (Personnel), Hobart House, Grosvenor London, S.W.1, marking envelope TT/871. testimonials should not be forwarded. Clos 13th December, 1954.

CITY OF BRADFORD

ENGINEERING ASSISTANTS

Applications are invited for the follow annuable appointments in the City Engi Surveyor's Department, on the grades indica (a) JUNIOR ENGINEERING ASSISTA Posts Nos. 65 and 173. Grade A.P.T. I IV (£490/£535, £520/£565, £550/£595 or according to qualifications).

(b) ENGINEERING ASSISTANT. Post Grade A.P.T. II, £520/£565 per annum.

Applicants should have had general expe municipal engineering and preferably Engineering Degree, and should have s their National Service.

Applications on the prescribed form to be from the City Engineer and Surveyor, Tow Bradford, 1, together with three testimon be received by the undersigned not later th day, 6th December, 1954.

No housing accommodation can be prov the Corporation.

W. H. LEATHE Town

Town Hall,
Bradford, 1.

FUEL RESEARCH STATIO

DEPARTMENT OF SCIENTIFIC A INDUSTRIAL RESEARCH

WORKS TECHNICAL OFFICER, GRA

Fuel Research Station, (Department of S and Industrial Research) require a WORKS NICAL OFFICER, Grade IV (unestablished on the erection of experimental chemical p bustion plants and be responsible for the sup of a small group of fitters. He will also have form some of the more highly skilled op Qualifications should include a full apprentic a general fitter. Salary range for a 44-hour day week £430 by £15 to £460 by £20 to £ minimum is linked to age 25, minus £ year below that age.—Apply in writing to Fuel Research Station, East Greenwich, SE later than 26th November, 1954.

COUNTY OF LEICESTE

ASSISTANT ENGINEER

ASSISTANT ENGINEER required with professional qualifications and experience design and supervision of construction mainly bridges. Salary £765–£825 per a

Application forms from the County Eng Surveyor, County Offices, Grey Friars, Le be returned by 27th November, 1954.

THE ENGINEER

NOVEMBER 19, 1954

"Comet" Court of Inquiry

FURTHER consideration of the cracks in the "Comet" fuselage has been given at the inquiry which continues at Church Hall, Westminster. Mr. W. Tye, chief technical officer of the Air Registration Board, maintained that the Board would pay more attention to the existence of manufacturing cracks. He stated that if the existence of these cracks had been pointed out before the Naples crash the Board would have intensified the examination of the affected structure before allowing the "Comets" to resume flying. Professor Murphy, Professor of Industrial Metallurgy at Birmingham University, agreed that fatigue had occurred in the "Comet" and broadly accepted the suggested technical causes of the disaster. On Thursday and Friday of last week the principal engineers of de Havilland Company gave evidence. It was stated that the metals used had been well tested earlier on other aircraft. The company's tests of the pressure cabin had "obviously missed the main line." The chief designer, Mr. Bishop, had ruled out the possibility of fatigue failure even after the third crash at Naples. It was thought that deterioration of the cabin structure had been brought about by gross handling such as might be caused by heavy landings. He was very surprised when the fuselage blew up after only the equivalent of 9000 hours had been spent in the tank at Farnborough. The company's whole test programme had been vetted by the Royal Aircraft Establishment. The cabin had been subjected to pressure tests which, it was thought, had proved it against a fatigue failure. It was stated that the company would have to do much more fatigue testing around the doors and windows and reduce the stress in those regions. There was also a discussion on the importance of distinguishing between cracks that propagated and those that did not.

Improvements at Surrey Commercial Docks

THE Port of London Authority has decided to proceed with a scheme for widening the cutting between the Greenland and Canada Docks in the Surrey Commercial Docks at an estimated cost of £365,000, as a step in the provision of additional berthing accommodation at these docks for some of the larger vessels which are now restricted to using the Greenland Dock. The present width of the cutting which is 60ft will be increased to give an effective width of 80ft (i.e. the same as that at the Greenland entrance lock) by setting back the wall on the north side, and the north-east corner of the cutting will be removed. The widening will enable vessels 450ft in length with a draught of 25ft 6in to pass through the cutting into Canada Dock as compared with 420ft and 23ft 6in, respectively, at the present time. Vessels up to a maximum length of 440ft will also be able to proceed from Canada Dock through the Canada/Quebec cutting which is already 80ft wide. A new single-leaf rolling lift bridge will replace the existing swing bridge over the cutting. It is estimated that the work will take over two years to complete. There is a popular misconception, the P.L.A. points out, that the Surrey Commercial Docks deal solely with ships carrying timber, mainly from Baltic countries, but the Greenland Dock has always been used by ships discharging or loading general cargoes. The new work now to be put in hand will eventually enable deep-draughted vessels carrying general cargoes to berth in the Canada and Quebec Docks as well. For general cargoes at the Greenland Docks, a new transit shed (No. 8), with an upper floor, 350ft long and 150ft wide, has been built on the south side at a cost of £170,000. The ground floor will allow cargo to be piled mechanically 20ft high and deliveries will be made by hoists from the upper floor. This new building will provide a berth for ships of the Scindia Line and there will be water access on both sides, enabling cargo for sorting and craft delivery to be taken direct through the shed to the South Dock. Modern 3-ton electric luffing cranes will be installed on the Greenland Dock side. On the opposite side of the Greenland-South Dock cutting and within a few feet of the new No. 8 shed is the recently built No. 2 shed, which is 325ft long by 90ft wide and is devoted to immediate delivery traffic from the Continent. At the west end of the Greenland Dock the work of rebuilding No. 12a shed has now finished. In both these new sheds the roofs have been taken up to allow for high-piling of general cargo.

Cycle and Motor-Cycle Exhibition

THE twenty-ninth International Cycle and Motor-Cycle Show, which was opened last Saturday by the Minister of Transport and Civil Aviation, closes to-morrow. This exhibition is probably the most comprehensive of its kind staged in the world. An ever-increasing popularity since the war attends the class of machines which is dominated by the scooter and includes the lighter and cheaper motorised cycle. One of the principal advantages of the scooter is the total weather protection for the driver which can be readily incorporated in its design as it is not handicapped by the need to provide for the cooling airflow around a centrally mounted cylinder. The enclosed design which is possible with the engine location on a scooter also leads to a cleaner machine. In spite of its advantages, however, it has not nearly approached the popularity that it has achieved on the Continent with both male and female riders. An attempt to provide greater weather protection for this class of machine was nevertheless, more evident at this year's exhibition. There are now over 1,000,000 licensed motor and motorised cycle owners in this country. The total home sale for motor-bicycles is likely to reach 100,000 by the end of the year, which would constitute an all-time record. Exports of motor-cycles are also approaching an all-time record and in the first nine months totalled 57,039, an increase of 16 per cent over the corresponding period last year. A total of 190,000 motor-bicycles will have been made by the end of the year. British bicycle production is the highest in the world and by the end of the year an estimated 3,156,000 machines will have been made. Home sales of bicycles alone are expected to exceed 1,100,000 machines.

Conference on the Automatic Factory

THE Institution of Production Engineers is arranging a conference in order to examine the implications of the automatic factory. It will be held at Margate from June 16 to 19, 1955. In making this announcement, the Institution says that, even though the wide scale existence of automatic factories is still a prospect of the future, it is essential to take a far-sighted view of the possibilities. To that end, it is intended that the discussions at the conference shall cover the technical, sociological and managerial problems arising from automatic factories. In particular, the impact on smaller factories is to be considered. Commenting on the decision to organise the conference, Sir Walter Puckey, president of the Institution of Production Engineers, said last week that any reference to automatic factories was news to laymen and technologists alike, and much superficial discussion—mostly conjecture—was taking place on the problems surrounding the subject. He claimed that the conference would be the first to be held in Great Britain exclusively on the subject of automatic factories, and the hope was that it would bring together managers, engineers, educationalists, scientists and sociologists to examine the matter. Major-General K. C. Appleyard, a past-president of the Institution, has been elected chairman of the conference committee, and Mr. A. F. Kelley has been elected chairman of a special sub-committee to arrange the conference programme.

Public Works and Municipal Services Congress

ELSEWHERE in this issue, we conclude a review of the exhibits at the Public Works Exhibition, which has been in progress at Olympia during this week. The week's events, however, also include the presentation of about thirty papers at the congress which is being held simultaneously with the exhibition. The papers are concerned with municipal, town planning and public health problems, and although in some cases they are not of direct concern to the engineering profession, they discuss topical problems of no little interest. For instance, a paper entitled "Car Parking in Central Areas," by C. D. Buchanan, draws attention to the controversial issues involved in adapting a city to modern traffic requirements; other, more strictly technical questions about modern highways, are examined in various other papers devoted to road construction and traffic engineering. Other papers which will interest engineers particularly include a review of air pollution problems entitled "Prevention of Atmospheric Pollution," by W. B. Kennedy. The use of modern plant in municipal and public works is also discussed in the papers before the congress. A subject which receives considerable attention is that of the treatment of sewage, particularly as it affects river pollution, and as it affects the choice of utilisation principally as fertilising materials, or of disposal of the end products. An abstract from one of the papers discussing this topic is printed on page 704.

London's Underground Railways

IT is announced that Mr. John Boyd-Carpenter, Minister of Transport and Civil Aviation, has given his consent to the inclusion in the British Transport Commission's Private Bill, to be introduced in the next session of Parliament, of enabling powers for the construction of a new underground railway from Victoria to Walthamstow via Green Park, Oxford Circus, Euston, King's Cross, Finsbury Park and Tottenham. This has been done so that the Commission can complete its working plans and be in a position to proceed with the works if and when a decision to carry out the scheme is reached. Neither the Government nor the Commission can yet enter into any commitment to carry out the project. This railway, known as route "C," with the associated part of route "D," is an underground railway route planned to run from Walthamstow to Victoria (route "C") and from this point to Fulham Broadway and Wimbledon (route "D"). In December, 1953, the Government announced that it was agreeable to the selection of route "C" with the associated part of route "D" from among the underground railway routes recommended in the London Plan Report as the first to be made the subject of detailed planning, including estimation of cost, and that the British Transport Commission was being so informed. It was pointed out that the final decision in regard to the undertaking of a major underground railway such as route "C" would have to be taken in the light of the investigations which the Commission would put in hand and in the light of available capital resources and economic conditions at the time. These investigations are not yet complete.

Stores Provisioning

By L. A. FERNEY

The provisioning of an engineering store, it is claimed, must be based not only on common sense but on sound engineering economics. This article examines the problem from the points of view of the logistician and the typical administrator

THE provisioning of a store is usually regarded as an administrative matter. A competent, methodical and conscientious administrator using common sense is believed to be capable of organising a store in such a manner that supplies are always on hand, that they are tidily stored, and expeditiously issued. No special qualifications or knowledge are believed to be necessary, except some technical knowledge of the products, their storage and buying procedures. So long as the aim of a store is merely to ensure the immediate (or rapid) supply of items in common use, the general administrator can fill the post admirably.

If, however, it is desired to obtain a store service of a certain standard at least possible cost, then store provisioning must be based not only on common sense, but also on sound "engineering economics" specially developed for this purpose. In the Armed Forces (of the U.S.A.) this branch of knowledge has been called logistics. The logistician, then, is the man who calculates what quantities at what times shall be ordered and stocked in order to satisfy a varying demand without (or with least) hitches, and at the lowest possible overall cost (including cost of any delays resulting from the occasional absence of certain items). The logistician must therefore have some mathematical knowledge and an understanding of statistical probability. He must use this knowledge to avoid empiricism and to base his decisions on correctly interpreted data from past experience, corrected for the effects of any forecast changes and events.

In the case of large industrial organisations using large varieties of materials and spares in order to maintain its production or service (steel works, mines, railways, airlines, public utilities) the more sophisticated logistic approach will reduce inventories by large amounts, in some cases some items by as much as 90 per cent. The kind of enterprises in question may each carry an inventory of consumable stores and spares (not production raw materials) of anything up to £10,000,000, which may sometimes be reduced with safety to £5,000,000, or even less by the correct approach. The problem is particularly acute in the case of a comprehensive enterprise in a remote part of the world—say, a large mine. Here, in addition to spares for the mining machinery, there must also be maintained spares for the utilities, services and amenities for a considerable population of the mines' township. Long and erratic delivery times must be allowed for.

In this article the approaches to the problem of stores provisioning by the typical logistician and the typical administrator will be examined and compared.

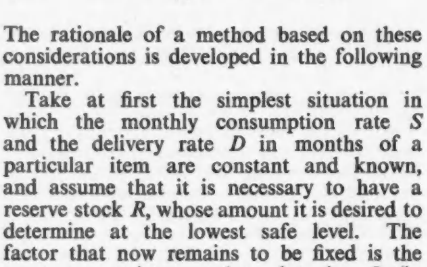
The Logistic Method of Provisioning

The objects of a correct stores provisioning policy are to minimise the storage costs of and to avoid losses ensuing from non-availability of items when required. These two aims are contradictory, and the best policy minimises the total costs due to both causes. But it is axiomatic that a stores that never runs out of anything is too big, provided that it is otherwise soundly organised. The rationale of a method based on these considerations is developed in the following manner.

Take at first the simplest situation in which the monthly consumption rate S and the delivery rate D in months of a particular item are constant and known, and assume that it is necessary to have a reserve stock R, whose amount it is desired to determine at the lowest safe level. The factor that now remains to be fixed is the most appropriate purchase lot size Q (in units). Assume that R and Q have been properly calculated (in a manner shown later). From Q and S we can determine the interval between orders T (in months) thus :

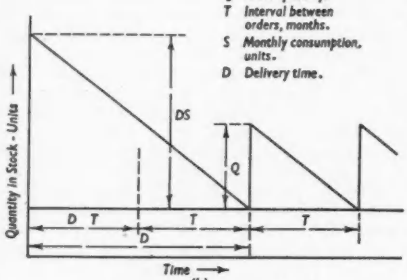
$$T=\frac{Q}{S}$$ (if $Q=500$ units and $S=100$ units/month ; $T=500/100=5$ months).

We can illustrate what happens diagrammatically in Fig. 1*a*. On a horizontal time



- KEY -

A Order point.
Q Order quantity.
T Interval between orders, months.
S Monthly consumption, units.
D Delivery time.



(a) The position in a steady state.
(b) Initiation of a new stock item.

Fig. 1—The logistic method of provisioning

basis are marked off two periods T. Vertically is plotted the quantity in stock. First we mark off and show the reserve R, below which the stock level is not normally expected to fall. By definition, a lot Q will be received at the beginning of each period, as shown by the line A_1B. The total stock is then equal to A ; normal consumption will gradually reduce it till at point B_1 only the reserve R will remain. This is due to the fact that we have deliberately made $Q=ST$; i.e Q is just big enough to last till the next lot arrives.

The maximum stock M is $=Q+R$ and the average stock will be $=\frac{1}{2}Q+R$.

Particular attention is drawn to the fact that in this reasoning Q is always equal to ST once supply and demand have reached a steady state. When it is decided to stock a new item a lot equal to SD units is ordered to be followed by lots $=Q$ at intervals of T months (see Fig. 1*b*).

Let us now consider what happens if our original assumptions, that the consumption rate and the delivery do not vary, hold no longer.

Should S grow, the reserve will be violated ; the steady state will be restored by ordering an extra lot (appropriately increased to the new value of S) at the point of violation. These more frequent and larger orderings are repeated, thus starting a new régime. If D becomes greater, the reserve is also violated, and stays at the lower level achieved, unless a special lot equal to the reserve violation is ordered on one occasion only. Thus the method works even if S or D do not remain constant.

We will now explain how Q and R should be calculated.

The Most Economical Purchase Lot.—There are three cost items involved in purchasing and storing a stock item :

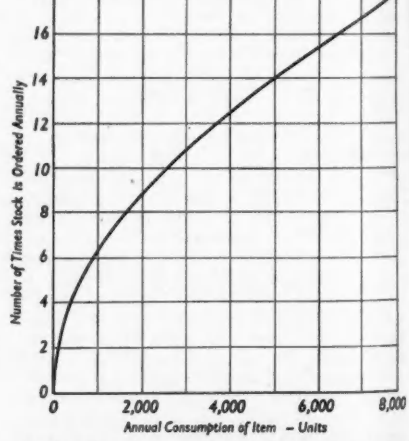
The clerical costs G of writing, &c., the order ; the capital charge CI on the average amount carried in stock (where C=cost per item, and I=interest rate), and the storage charge BE for the maximum number carried in stock (where B=shelf area per unit, E=annual cost of storage per square foot of shelf).

To minimise G per item, the order should be large ; to minimise the capital and storage charges the order must be small. It can be shown mathematically that the overall minimum is achieved when

$$Q=\sqrt{\frac{2GS}{CI+2BE}}.$$

In this formula S, the rate of consumption, plays a dominant role ; the bigger the S, the bigger is the economic purchase lot (see Fig. 2). The formula is thus self-correcting in respect of changes in S.

The Safe Reserve Stock.—This really consists of two parts : the strategic reserve R_1, and the operational reserve R_2. The determination of the first is the prerogative of higher management. Its level should be based on probabilities of war and calamities ; certain economic factors may also enter into consideration. It should be applied only to items so annotated by management. The strategic reserve level of every annotated item should be varied periodically as war and calamity risks change. It will be convenient, therefore, to express this reserve as "X months' consumption." The formula can then be changed by a blanket order :



Number of annual orders called for by logistic formula depends on the rate of consumption of the item : the greater the consumption the more frequent should be the orders.
Example.—If annual consumption is 1000 units, six orders are placed annually, each of 167 units.

Fig. 2—Effect of ordering most economic lots

"As from the . . . (date) . . . the strategic reserve of all annotated stock items will be changed from X months' consumption to Y

months' consumption." The determination of the strategic reserve need not rest entirely on hunches. The factors entering into the probability of a war can be scrutinised and, to some extent, assessed.

The operational reserve R_2 is required owing to uncertainties regarding the consumption rate and delivery time. The variabilities of these two factors can usually be ascertained by statistical calculations from past records, tempered when necessary by some forecasting. Once the future variabilities have been calculated (in a manner outlined in Table II) the level of R_2 can be worked out with any desired confidence limits. Thus, "if the calculated reserve stock of 500 units is maintained for item *A*, there is a calculated chance of 1 in a 100 (or 1 : 1000, or 1 : 50) that a requisition will not be met out of stock which will then be exhausted," i.e. the chance of being out of stock has been calculated in advance. The preset confidence limit must be related to the importance of the item for maintaining production. For an unimportant item a limit of 1 : 10 may be adequate ; for a very important item a limit of 1 : 1000 may have to be fixed.

Though the strategic and operational reserves have been treated separately here, the latter may be reduced by bringing the

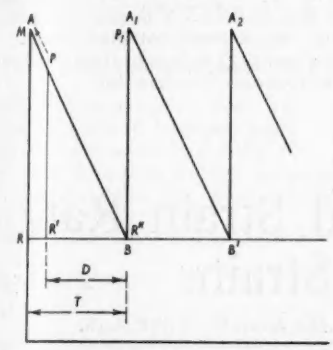


Fig. 3—The administrator's provisioning scheme

strategic reserve into the calculation. It then becomes possible to "borrow" from the strategic reserve to "repay" at a convenient time. By this means the total reserve may be fixed at less than the sum of the strategic and operational reserves.

Summary.—In the logistic method the important figures—purchase lot size and operational reserve level, are each calculated from the relevant factors. The first, on economic factors, the second on probabilities of running out of stock and the cost of such emergencies in lost production. A wise management may deem it prudent to carry an additional strategic stock reserve based on considerations of war and calamities risks.

The Administrator's Scheme

When the administrator begins to tackle the problem of stores provisioning he starts with the same data as the logistician : the monthly consumption rate *S* and the delivery time *D* (in months).

By definition he cannot calculate either the purchase lot or the reserve ; he tries to arrive at these two key figures from the two known to him by logical and empirical thinking, so that a safe and simple provisioning scheme is evolved. His reasoning runs as follows. He assumes that *S* and *D* are constant. He then fixes arbitrarily, but as realistically as possible :

The maximum stock *M* that the stores are to be allowed to carry at any time. (This is regarded as most important.)

The interval *T* (months) between successive re-orders.

The reserve stock *R* that the stores should always maintain.

To make *T* realistic it should be greater than the expected delivery time *D* ; e.g. if *D* is five months, the interval *T* may be made six months.

Let us now consider what happens during such an interval between orders (see Fig. 3 showing two such periods). By definition, the amount of stock in hand may vary from *M* at the beginning of the period to *R* at the end (this is represented by lines *AB* and A_1B_1), and fresh lots will have been received both at the beginning and end of the period. These arrivals are represented by lines A_1B and A_2B_1.

To ensure that lot A_1B arrives at point *B* (before the reserve is violated) it must be ordered *D* months earlier. Thus a realistic value for the re-order point *P* is established such that $PR_1=SD$.

If, then, on reaching the re-ordering level *P* a purchase lot *Q* is ordered equal to $M-R$ the task will have been completed ; having empirically set *M*, *R* and *T*, we have determined the ordering lot *Q*. (The reserve stock will be dealt with later.)

Let us now examine the implications of this procedure from the geometry of Fig. 3. Policy demands that the average stock shall be as low as possible, but the average stock $=R+\frac{1}{2}Q$. The smaller we chose *Q* (and consequently *M*) the smaller the average stock becomes. It therefore pays to fix *Q* as near as possible to its minimum value $-SD$, and, best of all, it pays to make $Q=SD$. In other words, the best solution the administrator can obtain is to make the purchase lot and the order level above the reserve each equal to the consumption during the delivery period *SD*. Having fixed *Q* and *P* in terms of the two known factors *D* and *S*, it seems logical and administratively desirable to fix the reserve stock level *R* on the same factors. This can be done in a variety of ways. Quite a logical one on the face of it is to make $R=Q=P$, and this the administrator often does.

Directly or indirectly, therefore, the administrator's provisioning scheme fixes stock levels on the basis of the delivery time : the longer the delivery time the higher will be the stock levels.

To consider the effects of this reasoning it is necessary to give some of the parameters' realistic values. Let us assume for this purpose that $D=6$ months.

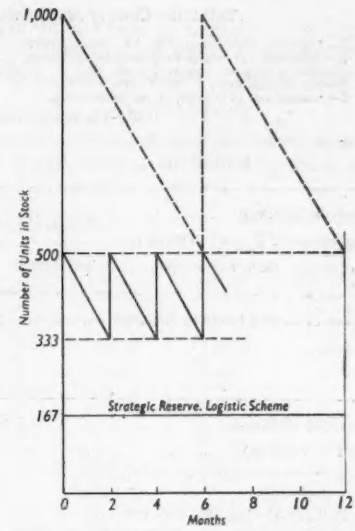
Then

$R=Q=P=6$ months' consumption.

and

$M=R+Q=2Q=12$ months' consumption.

Under stable conditions (*D* and *S* constant) it then follows :—



Numerical example when $S=1000$ p.a. and other parameters as in Fig. 2.

Administrator's scheme (broken lines)		Logistic scheme (full lines)
$Q=\frac{1}{2}S=$ 500		$Q = S/6 = 167$
$R=\frac{1}{2}S=$ 500		$R_1 = S/6 = 167$
$M=$ $S=1000$		$R_2 = S/6 = 167$
Av. stock ... $A=\frac{1}{4}S=$ 750		$R = S/3 = 333$
		$M = S/2 = 500$
		$A = 5S/12 = 416$

"*A*" is 80 per cent greater than for logistic scheme.

Fig. 4—A comparison between the two provisioning schemes

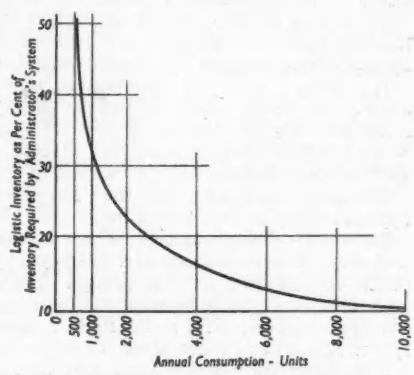


Fig. 5—Reduction in inventory from level fixed by a typical administrator's scheme by applying logistic theory

(*a*) The ordering lot is 6*S* and orders are placed twice a year.

(*b*) The maximum stock=12*S*.

(*c*) The average stock=9*S*.

(*d*) The reserve stock is never dipped into.

The advantages of this system are :—

(1) It is safe, as only in exceptional cases will the stores be out of stock.

(2) It is semi-self-correcting : increases in both consumption rate and delivery time are catered for by more frequent orders and increase in stock levels respectively.

Table I

Item	Administrator's plan (as per example quoted)	Logistic system
Strategic reserve	Not separately determined	Determined and reviewed periodically by higher management
Operational reserve	Not separately determined	Calculated from consideration of importance of part, variabilities in consumption rate and delivery time
Total reserve	Empirically based on annual consumption ($=\frac{1}{2}S$)	Determined from the two reserves
Purchase lot	Empirically fixed (at $\frac{1}{2}S$)	Calculated from a formula giving the most economic size
Number of annual orderings	Arbitrarily fixed (at two under steady conditions)	Varies from item to item, mainly in accordance with the consumption rate
Average stock carried (when consumption constant)	Three-quarter year's supply ($=\frac{3}{4}S$). In most cases much higher than need be	$10\sqrt{S}$ which is always less than on other system, provided *S* is greater than 177 units per annum
Cost of carrying stock (interest, storage and ordering)	Approx. 7–8 per cent of value of one year's consumption	Varies between 3 to 4 per cent of value of one year's consumption

TABLE II—*Costs of Maintaining Inventory for Both Provisioning Systems*

G—Clerical costs for preparing, &c., order, 25shgs.
C—Total cost per item of store considered, 20shgs.
I—Interest rate per annum, 7·5 per cent.
B—Net storage area per unit of item, 0·05 square feet.
E—Annual cost of storage, 5s. per square foot.
S—Annual rate of consumption.
N—Number of annual orders (for administrator's system = 2.)
M—Maximum stock carried.
R_s—Operational reserve = Q.

(*N.B.*—The strategic reserve expense is calculated separately.)

Expense item	Administrator's system	Logistic system
Clerical cost (Shillings)	$2\times25=50$	$25N$
Interest charge = $C\,Q_{AV}\times I$ (Shillings)	$1\cdot5\times0\cdot75S=1\cdot125S$	$1\cdot5\times1\cdot5Q=2\cdot25Q$
Storage charge = $BE\times M$ (Shillings)	$=0\cdot250S$	$0\cdot25\times2Q=0\cdot50Q$
Total cost of carrying inventory (Shillings)	$50+1\cdot375S$	$25N+2\cdot75Q=\frac{25}{5}\sqrt{S}+2\cdot75\times5\sqrt{S}=18\cdot75\sqrt{S}$ But $Q=5\sqrt{S}$. and $N=\frac{S}{Q}=\frac{S}{5\sqrt{S}}=\frac{\sqrt{S}}{5}$
If $S=10{,}000$ (Shillings)	13,800	1875
If $S=1000$ (Shillings)	1,425	594

The disadvantages are :—

(1) Decreases in consumption rate or delivery time are not automatically corrected.

(2) Directly or indirectly, this provisioning scheme fixes stock levels on the basis of the delivery time : the longer the delivery time the higher will be the stock levels.

Delivery time as used here covers the whole period from the writing out of the requisition to the binning of the incoming stores from suppliers. It comprises nine steps. Most of these can be controlled by the administrator and kept as low as possible by expeditious progress of the paper work.

It is likely that higher management, in its anxiety to reduce inventory values, closely scrutinises every requisition at various stages of its progress towards becoming an order. This will lead to a cumulative increase in the procurement time and will thus have the opposite effect to that hoped for.

Summary.—The above conclusions require that every item be ordered $12/T$ times yearly (if the consumption remains steady). There is no differentiation between operational and strategic reserves. To make such a rigid system safe, its originators fixed the reserve at a high figure (in some cases it may be ten times greater than need be).

The system is safe but extravagant.

COMPARISON BETWEEN ADMINISTRATOR'S AND LOGISTIC SYSTEM

It is claimed that a provisioning system based on logistic considerations is more economical and just as "safe" as the empirical "administrator's" system. "Safety" here means remoteness of the chance of running out of stock of important items. On this score the logistic system has the advantage of being based on calculated risks in the light of previous and anticipated experience. Calculating Q by our formula gives the number of times per annum stock has to be re-ordered. The larger the consumption the more annual orderings does the formula prescribe.

Common sense alone shows that the shorter the intervals between receipt of lots, the smaller may the reserve stock be kept with the same degree of safety. Statistical calculations covering this and other relevant points will prove this statement.

Fig. 4 illustrates the stock positions for both the administrator's and the logistic systems for an item with an average annual consumption of 1000 pieces. The other parameters are as in Fig. 2. The logistic scheme is shown as having a distinct strategic reserve = $S/6$ (where S = annual consumption rate of the item). Fig. 5 (also based on Fig. 4 parameters) shows the reduction in inventory when using the logistic system as compared with the administrator's system.

Figs. 2, 4 and 5 are intended as illustrations ; the shapes of the curves will in all cases depend on the parameters chosen.

In the examples chosen the cost of keeping the administrator's inventory will be about 7 to 8 per cent of the purchase cost of one year's consumption of the item ; the corresponding cost of the logistic inventory will be 3 to 4 per cent for items having a reasonable annual consumption rate (see Table II).

Conclusions are summarised in Table I.

MATHEMATICAL NOTE ON STORES SYSTEMS IN STATISTICAL EQUILIBRIUM

A store may be said to be in statistical equilibrium when the rate of withdrawal of stock though not constant, varies about a known rate in accordance with a known distribution. This is a type of system that will frequently occur in a maintenance store. Whatever level is chosen for ordering in such cases, there will always be some risk of running out of stock ; the problem is to choose the ordering level to ensure that the risk deemed acceptable for the item is reached, but not exceeded. For the case below, the chance of running out of stock is taken as 1 in 1000. If the rate of consumption is taken as S, and the standard deviation of the rate of withdrawal is s, the rate will vary between $(S+3s)$ and $(S-3s)$ for the 1 in 1000 level. If the procurement time is D the estimate of stock consumption is

$$D(S\pm3\sqrt{s/D})$$

over the procurement time D. It is a well-known property of a series of D samples, each of standard deviation s, that the standard deviation of the grouped samples is

$$=\frac{s}{\sqrt{D}}.$$

So, due to the variation of withdrawal rate, the consumption can vary between $DS-3s\sqrt{D}$ and $DS+3s\sqrt{D}$. Hence, the order level is $DS+3s\sqrt{D}$, plus an additional strategic stock level that may be set. The order quantity Q is derived from the formula for the economic purchase lot.

Lateral-Longitudinal Strain Ratio for Plastic Strains

By T. F. W. SMITH, A.M.I.C.E., A.M.I.Mech.E., A.F.R.Ae.S.

The ratio of lateral to longitudinal strain, known as Poisson's ratio for elastic strains, is usually taken as 0·5 for plastic strains. This ideal value, however, is only applicable to very small strains and provided the volume of the material is unchanged. The variation of the ratio with strain and the effect of changes of volume are discussed.

THEORY

LET e_p be the longitudinal plastic strain under simple direct stress and let Δ_p be the corresponding plastic volumetric strain, strains being measured by the usual engineers' method as fractions of the original dimensions with tensile strains positive and compressive strains negative.

Then if the ratio of lateral to longitudinal strain be σ_p :

$$\Delta_p=(1+e_p)(1-\sigma_p e_p)^2-1$$

Therefore

$$\sigma_p=\frac{1}{e_p}\left(1-\sqrt{\frac{1+\Delta_p}{1+e_p}}\right) \quad . \quad . \quad . \quad . \quad (1)$$

This equation when plotted for various values of Δ_p gives the dotted curves shown in Figs. 1 and 2. It is seen that for constant volume when $\Delta_p=0$ the curves become, with negligible error, the straight lines :

$\sigma_p=0\cdot5-0\cdot35e_p$ for tensile straining with e_p positive (see Fig. 1) . . . . . (2*a*)

and

$\sigma_p=0\cdot5-0\cdot40e_p$ for compressive straining with e_p negative (see Fig. 2) . . (2*b*)

Now let the volumetric strain Δ_p be expressed as ae_p where a is a small fraction.

Then :

$$\sigma_p=\frac{1}{e_p}\left(1-\sqrt{\frac{1+ae_p}{1+e_p}}\right)$$

$$=\frac{1}{e_p}\left(1-(1+ae_p)^{\frac{1}{2}}(1+e_p)^{-\frac{1}{2}}\right)$$

$$=\frac{1}{e_p}\left(1-(1+\tfrac{1}{2}ae_p-\tfrac{1}{8}a^2e_p^2+\ldots\ldots)\times(1-\tfrac{1}{2}e_p+\tfrac{3}{8}e_p^2+\ldots\ldots)\right)$$

$$\sigma_p=\frac{1}{e_p}\left(0\cdot5e_p-\frac{a}{2}e_p-e_p^2\left(0\cdot375-\frac{a}{4}-\frac{a^2}{8}\right)+\text{small terms}\right)$$

$$=0\cdot5-\frac{a}{2}-e_p\left(0\cdot375-\frac{a}{4}-\frac{a^2}{8}\right)+\text{small terms.}$$

By graphical plotting it is found that this is very nearly :

$\sigma_p=0\cdot5-0\cdot35e_p-\frac{a}{2}$ for tensile straining . . . . . (3*a*)

and

$\sigma_p=0\cdot5-0\cdot40e_p-\frac{a}{2}$ for compressive straining . . . . . (3*b*)

where

$$a=\frac{\Delta_p}{e_p}.$$

For a constant value of "a" these equations become straight lines parallel to the constant volume line as shown in Fig. 1 for $a=0{\cdot}02$ and $0{\cdot}04$.

Experimental Work

Tensile tests have been made in which e_p and σ_p were determined from measurements

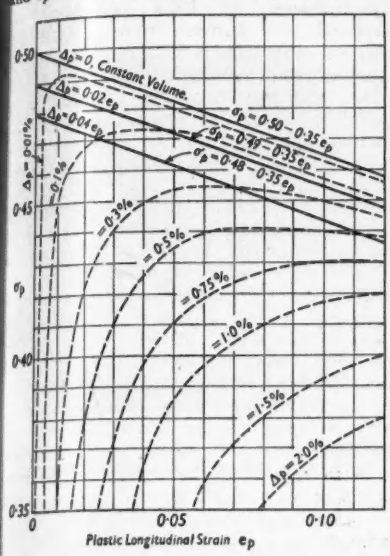


Fig. 1—Curves calculated from equation (1) for tension

of extension by vernier callipers and of contraction of diameter by micrometer. The specimens, which were of mild steel, alloy steel, aluminium alloy and magnesium alloy, were ¾in diameter with gauge lengths of from 5cm to 10cm.

The results are shown graphically in Fig. 3.

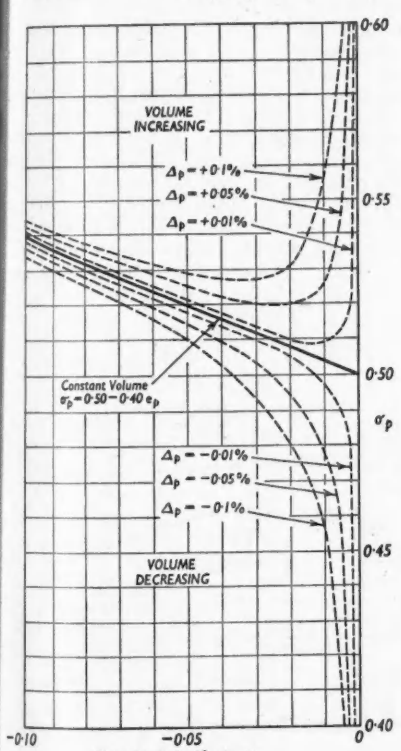


Fig. 2—Curves calculated from equation (1) for compression

Although the means of measurement were not of great accuracy, they were considered adequate to demonstrate the approximate linearity of the σ_p, e_p relationship. No large deviation from the constant volume line was found, the greatest being with steel which gave a value of a of about $0{\cdot}04$, indicating permanent changes of volume of about $0{\cdot}04$ times the longitudinal strains. It may be noted that changes of volume of this order were found by Ueda[1].

Compressive tests have also been made in which the density of specimens before and after plastic straining was measured by weighing in air and water. The specimens were of mild steel, alloy steel, aluminium alloy, magnesium alloy, copper and phosphor bronze, and were about ¾in diameter and ⅞in long.

The results are given in Table I. All the changes of density were very small and their effect on σ_p would be negligible. It may be noted that for mild steel similar changes of density were found by Lea and Thomas[2].

Conclusions

In conclusion, it may be stated that the linear equations $\sigma_p=0{\cdot}5-0{\cdot}35e_p$ for tension, e_p being positive, $\sigma_p=0{\cdot}5-0{\cdot}40e_p$ for compression, e_p being negative, may be used to determine the value of σ_p where the volume remains constant.

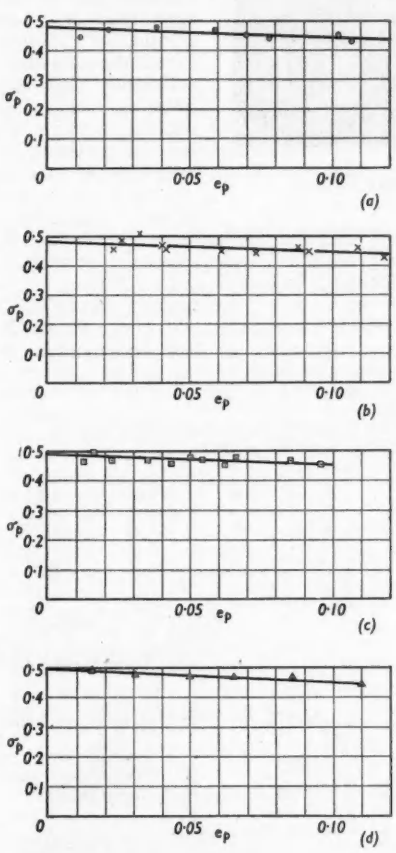
The volumetric changes in metals are, in fact, generally negligibly small, but where they are not, they may be allowed for by reducing the value of σ_p by $\frac{\Delta_p}{2e_p}$. Such reduction is unlikely to exceed about $0{\cdot}02$, this value occurring in steels under tension.

The tests were made in the mechanical engineering department of Brighton Technical College. Professor J. J. Guest initiated the tests.

Table I—*Results of Compression Tests*

Material	Specimen No.	Nominal stress, tons/in²	Amount of compression	Density before loading, gm/c.c.	Density after loading, gm/c.c.	Percentage change in density (+for increase)
			Per cent			Per cent
Mild steel (annealed)	1	47·5	17·5	7·8525	7·8495	−0·038
Edgar Allen A13 alloy steel* (annealed) ...	1	56·5	14	7·8603	7·8585	−0·023
Aluminium alloy HE 14T	1	47	18	2·8071	2·8052	−0·068
Magnesium alloy	1	16·25	8	1·7754	1·7765	+0·062
	2	19·5	8	1·7752	1·7768	+0·090
Copper	1	27	23	8·9258	8·9273	+0·017
	2	45·3	49	8·9252	8·9248	−0·005
Phosphor bronze, 6 per cent Sn...	1	45·3	16	8·9313	8·9329	+0·018
	2	79·3	43·5	8·9335	8·9302	−0·037

* The A13 steel is a nickel-chromium-tungsten steel normally used in the hardened and tempered condition. In these and the tensile tests (see Fig. 3) it was in the annealed condition for maximum ductility.



a) "Keystone" mild steel (annealed), two tests.

(*b*) Edgar Allen "A13" alloy steel (annealed), two tests.

(*c*) Aluminium alloy HE14T," two tests (material provided by the Aluminium Development Association.)

(*d*) Magnesium alloy—experimental composition approximating to "ZW1," one test (material provided by Magnesium Elektron, Ltd.).

Fig. 3—Experimental values of σ_p for various metals

References

[1] "On the Effect of Cold Working on the Density and Electrical Resistance of Metals": Taro Ueda, 1930, Tohoku Imperial University Science Reports, first series, Vol. 19, Page 473.

[2] "Change in Density of Mild Steel Strained by Compression Beyond the Yield Point": Lea and Thomas, *Engineering*, July 2, 1915.

Micro-Sizing on Centreless Grinding Machines

An automatic micro-sizing equipment for use on centreless grinders has been developed by Arthur Scrivener, Ltd., Tyburn Road, Birmingham, to eliminate need for a machine operator to adjust the control wheel or grinding wheel manually through a graduated index wheel for the correct sizing of work. The hydraulically-operated push-button micro-sizing device is so arranged that pressure on the button turns the fine-feed shaft of the machine a predetermined amount. The actual distance the wheel head is fed forwards at each depression of the button is determined by the setting of a graduated selector knob on the top of the device. This knob gives a range of five feed increments from 0·0001in to 0·0005in.

This device is push-button operated but an alternative form is fully automatic, being arranged for electrical operation under the control of accurate pneumatic measuring equipment when a machine is on through-feed centreless work. The continuous automatic device utilises the twin-jet ring gauge of the Sigma Instrument Company, Ltd. Work passing out of the grinder is continuously fed through the ring gauge, which has two measuring jets and a monitoring jet. The monitoring jet ensures that the measuring jets only function when work is actually in the gauge, so that the intermittent gaps caused by the passage of the ends of the workpieces through the gauge have no effect upon the accurate recording of the size. A controller under the influence of the measuring jets is arranged to switch power impulses to the micro-sizer when the size of the work being gauged reaches the upper tolerance limit.

Experimental Axial-Flow Blower at the University of Birmingham

By J. W. RAILLY, M.Sc., A.M.I.Mech. E.*

PROBLEMS in the aerodynamic design of gas turbine components, particularly in the field of the rotating machinery, lead to long and costly research and development programmes. The high degree of finish and precision which is necessary for efficient working requires the application of many new techniques of machining and manufacture. In addition, to obtain useful information at the high Mach numbers in aircraft compressors and turbines, the provision of a large power output or compressed air supply, running into thousands of horsepower, is practically unavoidable.

Fig. 1—Axial machine and dynamometer installed at the University of Birmingham

These considerations are uppermost in deciding the question of whether a university department can usefully tackle problems of this nature. However, one important point emerges from an examination of the possibilities ; this is the extent to which problems arising from compressibility of the working fluid affect the behaviour of the compressor and turbine components. It seems to be fairly clear that many problems of three-dimensional flow distribution in rotating machinery are not greatly different under conditions in which density changes may be neglected. If this be the case, then it is possible to obtain useful information about such flow problems in cases where the power expenditure with an experimental machine can be considerably less than a machine of the same dimensions running with high Mach numbers.

Howell† has pointed out that very useful results following this principle can be obtained by means of a " water-compressor " in which full-scale Reynolds numbers are obtainable with almost negligible power expenditure and with quite low rotational speeds, thus making possible the use of such easily castable materials as Woods' metal for the blades. Howell stated further that such an approach might usefully be employed by university engineering departments.

When the writer joined the staff of the mechanical engineering department in 1950 preparations were going ahead under the direction of Professor F. K. Bannister for the initiation of a graduate school in thermodynamics and related studies.‡ In order that the School would be able to provide the students with an up-to-date knowledge of recent developments and of modern techniques a wide range of equipment was required. The writer suggested that in the field of axial turbo machinery the best policy would be to obtain a three or four-stage axial machine handling cold air which would be fully instrumented for flow investigation, employing cheap and easily renewable blades with adjustable stagger, and running at such a speed that compressibility effects were not encountered.

Although a machine handling air requires a larger power and speed than the " water compressor " mentioned above, to obtain sufficiently high Reynolds numbers (of the order of 1 to 3×10^5), it does have the advantage that the machine can be fitted in with other experimental rigs requiring low-pressure air, such as an experimental low-pressure combustion chamber. In addition, the adoption of air as the working fluid permits the use of the hot-wire anemometer, which can be a valuable instrument for flow investigation between the blade rows, particularly where turbulent conditions exist and where turbulence itself is an important variable quantity.

In view of the excellent machining capacity in the workshop of the department, it was decided to go ahead with the manufacture of a three-stage axial-flow machine to the writer's design. The department was fortunate to obtain, second-hand, a B.T.H. dynamometer, for 250V d.c., which was supplied with current from a 60kW d.c. machine driven from the three-phase supply. The maximum speed was 4500 r.p.m., so that for the power available the mechanical design presented no great difficulties. As further equipment for the graduate school a single-stage radial blower was ordered from Keith-Blackman, Ltd., which could be used for drawing air through the axial machine when it was equipped with a set of turbine blading. With the Ward-Leonard type of drive and by the fact that the overload capacity of the dynamometer was considerably larger than the current normally required, the torque of the turbine could be measured down to quite low speeds and finally the standstill torque could be measured by locking the rotor to the casing. In Fig. 1 a view is seen of the axial machine and dynamometer.

With regard to the design of the axial machine, it was felt that advantage should be taken of the comparatively low speed to provide good inlet conditions by employing an overhung rotor. This avoided having a bearing suspended by a spider in the air stream, as it was known that the wakes from the unavoidably rough character of these supporting spiders considerably affected the flow on to the first rows of blades. In this design only three thin struts are necessary to support the rotor fairing. With a total of seven rows of blading in the machine it was decided to use the split form of construction, as this aided the problem of rapid assembly after dismantling. In addition, it provides for an easy inspection of the blading. The form of construction employed (Fig. 2) consisted of a single forged rotor with a considerable degree of overhang on either side of a central disc, this being possible since the stresses were not severe. The rotor accommodates three rows of blades with a slightly different spacing between the second and third rows to permit the insertion of a

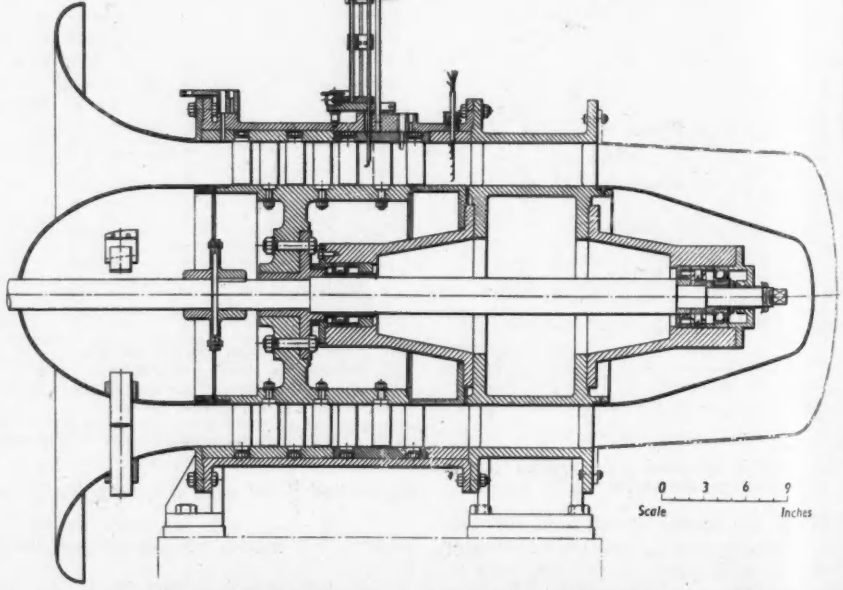


Fig. 2—Sectional arrangement of axial flow machine. The single forged rotor has considerable overhang on each side of the central supporting disc

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† *Proc. I.Mech.E.*, 1950, Vol. 163, page 235.

‡ A full description of the Graduate School in Thermodynamics and Related Studies was given in THE ENGINEER of April 16, 1954.

variety of total head and yaw tubes at this point. Fig. 3 shows the finished bladed rotor carrying three rows of untwisted compressor blades in aluminium silicon alloy. The stator half-casings are each made in two parts. The outer casing carries the end flanges and side flanges together with gear for moving two of the rows of stator blades in a peripheral direction (Fig. 4). The

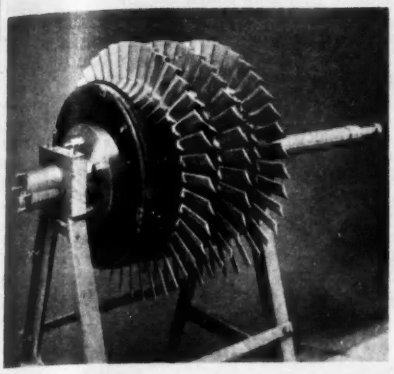


Fig. 3—The rotor carries three rows of untwisted compressor blades in aluminium-silicon alloy

traverse gear is also mounted in a fixed position on the top half casing. The inner stator half-casings each consist of three half-rings, two of which have holes drilled in them for blade fixing, the third being a spacer ring. Two of these rings are fixed to the outer half casing while the third half-ring, being retained axially and radially by the other two, can move freely in the peripheral direction. The advantage of this form of construction is threefold. First, in an experimental machine some provision must be made for obtaining the peripheral variation of the flow in the wakes following the previous stationary blade row, and in this design it is accomplished by moving the last two stator rows through a circumferential distance of two blade pitches. Secondly, this method permits the easy removal to a face plate of the four half portions of stator blading, whereby the adjustment of the blade angles may be easily carried out to a good degree

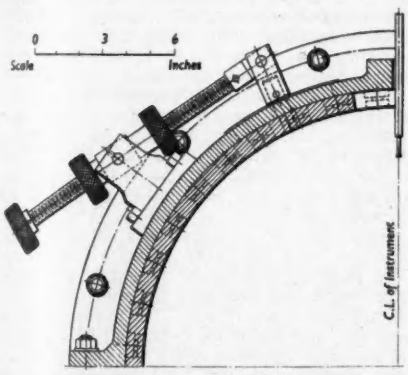


Fig. 4—Gear for moving two of the rows of stator blades in a peripheral direction

of accuracy, this being most important if consistent results are to be obtained. Finally, if it is desired to change number and pitch of stator rows or the number of blades per row, the provision of a second set of half-rings is comparatively easy, as it is not necessary to disturb the machine on its foundations.

The great problem of using this kind of equipment in a university is that of obtaining, quickly and cheaply, different sets of blading, made with a sufficient degree of precision and surface finish in all the complicated shapes that may be required. At the outset the use of blades made in cast resin (phenol-formaldehyde) was considered, but the fatigue strength of the material in this state was not quite adequate and there were no advantages in speed of manufacture. The use of an aluminium alloy blade made by gravity casting in a steel die, with subsequent machining of the root, seemed to offer the best solution provided a die could be cheaply made. Starting from a steel pattern with double shrinkage allowance, a stainless steel die in two halves was made by Precision Products, Ltd., of Cumberland, using the Osborn-Shaw process of precision casting. The die required a small amount of hand finishing and proved satisfactory, pouring with 10 per cent aluminium-silicon alloy. This work was carried out using the facilities provided by the department of metallurgy.

The axial machine is intended to be part of a single low-pressure air rig. Part of this rig is now complete, being an atmospheric pressure combustion chamber of the aircraft type, which may be supplied by the axial and radial machine in series to obtain the maximum mass flow and heat output. The combustion chamber, outlet traverse gear, and a "P.C.6" fuel pump, were given to the department by J. Lucas, Ltd.

When the axial machine is equipped with a set of turbine blading the radial blower will draw air through the machine and the power (about 27 h.p. maximum) will be absorbed by the dynamometer. To facilitate the change over to this blading a complete set of half-rings with the turbine blading fixed, together with a second rotor, is intended.

With the axial machine running as a blower the two machines in series will also supply a small-size wind tunnel for graduate school experiments in heat transfer and boundary layer investigations. The pressure ratio from the two machines will be 1·2, so that, provided there are no models in the tunnel and by recovery of the kinetic energy, Mach numbers in the transonic region should be obtainable. The actual tunnel working section has, to date, not been completed.

The writer wishes to thank Professor G. F. Mucklow, the head of the department, and Professor F. K. Bannister. He also wishes to pay tribute to the fine quality of workmanship carried out by the workshop staff.

Coal Carbonisation Plant at Fishburn, Co. Durham

The National Coal Board has planned the construction of a series of coal carbonising plants, and the first of them to be completed is at Fishburn, Co. Durham. This new plant, which began operation in August, has replaced two older coking plants; it has a daily carbonising capacity of 1000 *tons of coal.*

THE National Coal Board has seventeen coking plants in the Durham Division, which carbonise over 4,000,000 tons of coal a year and produce nearly 3,000,000 tons of coke, including 750,000 tons of foundry coke. The coke oven building programme which the Board has in hand provides for the replacement of such plants as are, on account of age and design, difficult to maintain and operate efficiently. In deciding on the best situation for the new plants in the north, however, it has been necessary to give particular attention to the changing nature of the Durham coalfield and to the reorganisation plans for the mines.

The Coal Board's immediate construction programme up to 1958 includes new coking plants at Fishburn, Lambton and Murton, each to carbonise initially 1000 tons of coal a day, and the doubling of the Monkton plant which will then be able to deal with 1300 tons of coal daily. The new Fishburn plant, which has replaced two old plants built in 1915 and 1919, is the first of four new coking plants. Together with existing ovens at Brancepeth and Stella Gill, it will be able to supply daily 40,000,000 cubic feet of purified gas to the Gas Board's grid system in addition to 20,000,000 cubic feet of unpurified gas which is available from the Norwood, Derwenthaugh and Trimdon coking plants.

The plant at Fishburn will produce mainly furnace coke, and is well situated for the despatch of such coke to the Tees-side steel works. It is built adjacent to the Fishburn colliery, which supplies the greater part of its coal requirements. The installation includes fifty "W-D Becker" combination underjet coke ovens; coal handling, blending and crushing plant; coke handling and screening plant; and by-product recovery and crude benzole plants, for all of which the main contractor was Woodall-Duckham Construction Company, Ltd., 63–77, Brompton Road, London, S.W.3. The annual production of the Fishburn plant is put at 250,000 tons of coke, 3,250,000 gallons of tar, over 1,000,000 gallons of benzole, and 4000 tons of grade I sulphate of ammonia, as well as the supply of purified gas already mentioned.

The Coke Oven Batteries

A drawing showing the general arrangement of the plant is given in the art plates facing page 698, and some photographs of various parts of the installation are reproduced. The ovens, which are arranged in two separate batteries of twenty-five each, are built in line with the coal storage bunker at one end and the stack at the opposite end. Each oven is 40ft 9½in long between the doors, and 13ft high, the average width being 18in and the capacity 735 cubic feet. The ovens have been designed for heating either by coke oven gas when the underjet system is employed, or, alternatively, by producer gas when producer gas mains are added at a future date.

The fuel gas piping and the underjet firing controls are situated in a spacious basement below the battery structure which is supported on reinforced concrete beams and columns. Part of the basement is shown in an accompanying illustration. The pinion wall at each end of each battery is constructed of brick with a steel grillage and is supported independently of the concrete pad. The battery bracing consists of spring controlled rigid steel members, the springs of which can be adjusted to a predetermined pressure. The waste gas flues, which are of reinforced concrete lined with firebrick, are built along the sides of each battery to connect with the stack at the end. The stack is 225ft high and is lined with firebrick for the first 70ft above the waste gas flue inlet.

The heating system consists of a series of vertical flues on each side of each oven connected by cross-over flues over the top of alternate ovens. Beneath each series of vertical flues and connected to them there are two regenerators, each of which is divided by a central division wall into two sections of half-oven length. When coke oven gas is used as the heating medium the underjet system is employed and half the regenerators (alternate fours in the

length of the battery) are utilised to preheat the air. The coke oven gas is fed from the fuel gas main through connections carrying the reversing and isolating valves, to alternate pairs of cross-header pipes in the basement beneath the battery structure. From the cross-headers, of which there is one beneath each pair of regenerators, pipe connections lead the gas to the vertical ducts in the wall between the two regenerators. The gas passes up through the vertical ducts to the base of the vertical heating flues where it meets the preheated air and combustion begins. The contour of the flues from the regenerators up which the preheated air travels is such that the air and gas meet with a streamline effect and the burning gas is distributed throughout the length of each vertical flue so that even heating of the ovens is obtained. Combustion takes place along the entire length of an oven wall simultaneously.

The products of combustion are collected from each group of vertical flues and carried over the top of the oven by cross-over flues. There are eight of these cross-over flues to each alternate oven, none being required for the intermediate ovens, and from them the waste gases are distributed into and pass down the vertical flues on the other side of the oven exactly opposite the flues up which they have travelled. The waste gases then travel down from the vertical flues into the two regenerators beneath, through which they pass into the waste gas flues, giving up heat in transit. The air for combustion is preheated in its passage up and through the regenerators which it enters at the bottom and at both ends of the oven simultaneously. Upon reversal of the valves, which is automatically controlled and occurs at thirty-minute intervals, the coke oven fuel gas is fed through the alternative pairs of cross-header pipes and vertical ducts and the air passes up through the regenerators down which the waste gas has previously passed. To compensate for the increased oven width on the coke side, the calibrated nipple in each fuel gas pipe connection leading to the vertical ducts is increased in area and the air ports at the bottom of the vertical combustion flues are increased in width throughout the length of the oven. The gradation of orifice and port width ensures that the whole of the charge is evenly carbonised.

When producer gas is used as the heating medium the regenerators are utilised to preheat both the producer gas and the air. The producer gas and the air enter the bottom of their respective regenerators at both sides simultaneously. After being preheated in their passage through the regenerators, the gas and air pass through specially designed ports and meet at the bottom of the vertical flues where combustion begins. From this point onwards the flow of burning gas and waste gas is similar to that described for coke oven gas, except that the regenerators preheat both the producer gas and the air. The design of the regenerators is such that a regenerator preheating air is always positioned between the regenerator through which the producer gas is passing and that through which the waste gas is passing. Consequently there is no possibility of the producer gas leaking into the waste gas regenerator.

The battery control room is situated at bench level at the ovens' coal bunker end of the battery. The reversing machine, which operates the fuel gas cocks and the air and waste valves, is placed in this room and is provided with totally enclosed gearing running in oil. Normally, the machine is operated by an electric motor, but there is also a steam engine standby which can be used in case of a power failure.

Coal Handling, Blending and Crushing

As already stated, most of the coal for the plant is taken direct from the washery and screens of the adjacent Fishburn colliery, although there is provision for coal to be brought in from other collieries. A system of belt conveyors from the washery delivers coal of minus ½in size at the rate of 330 tons per hour to twenty reinforced concrete blending and storage bunkers which are arranged in two rows of ten, each bunker having a capacity of 200 tons. At the top of the bunkers a reinforced concrete head house accommodates a reversible 60in belt conveyor and two 42in shuttle belt conveyors which receive the coal from the washery and deliver it into the bunkers as required. At the bottom of each bunker there is a hoppered outlet provided with a rack and pinion operated door to control the discharge of coal on to the travelling belt feeders beneath. There are eight travelling feeders, four for each row of bunkers, and they run on tracks laid in the floor beneath the bunkers. Each feeder has an adjustable feed to its 42in belt which is electric motor-driven through variable speed gears and is capable of handling 80 tons of coal an hour.

A 42in belt conveyor, running centrally between the two rows of bunkers, receives the coal from the feeders and delivers it, at the transfer station, on to an inclined belt conveyor, which in turn elevates the coal and delivers it at the crusher house directly into the chutes feeding the crushers. The crushers are duplicate swing hammer pulverisers arranged so that both are in operation simultaneously. Each machine is direct-driven, through a flexible coupling, by an electric motor and is capable of reducing the coal so that 80 per cent passes through a ¼in square mesh. From the crushers the coal is discharged through a dust-tight delivery chute with an air expansion chamber and collected on a 60in belt conveyor which, in turn, feeds it on to the 36in inclined belt conveyor which elevates it and delivers it at the top of the ovens' coal bunker. Here it is received by a 48in rotary shuttle belt conveyor which distributes it in the bunker as required.

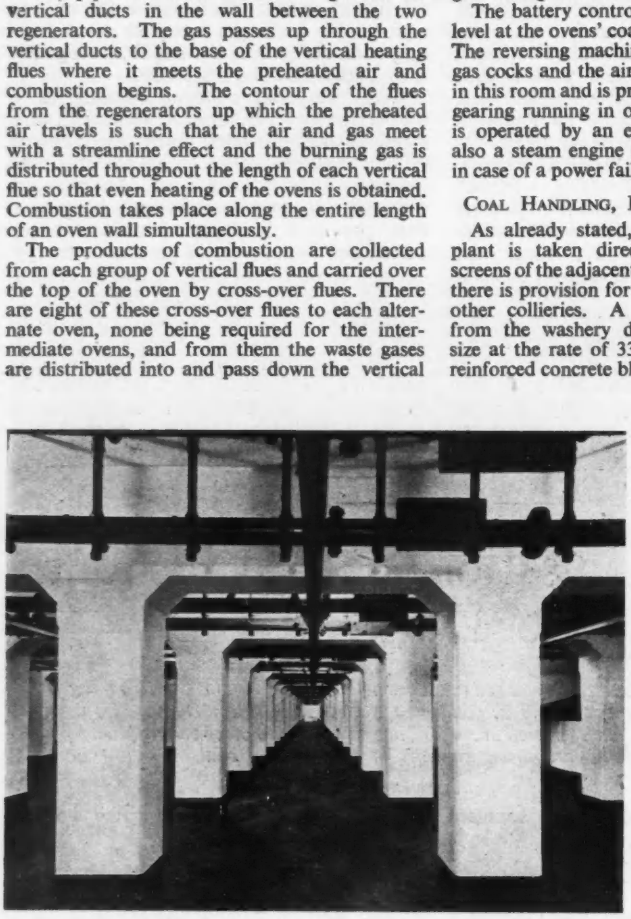
The inclined conveyor, which is approximately 450ft long, is tandem-driven and is carried in a braced frame gantry provided with "Perspex" sheeting lights. The coal handling plant from the blending bunkers onwards has a capacity of 300 tons per hour. The reinforced concrete ovens' coal bunker has a total capacity of 3000 tons of washed crushed coal, and is approximately 145ft high. There is a separate compartment of 600 tons which can be used as a test compartment if required. There are twenty discharge gates which are connected in rows of four per bay and operated by hand winches from a platform below the bunker.

Oven Charging and Discharging

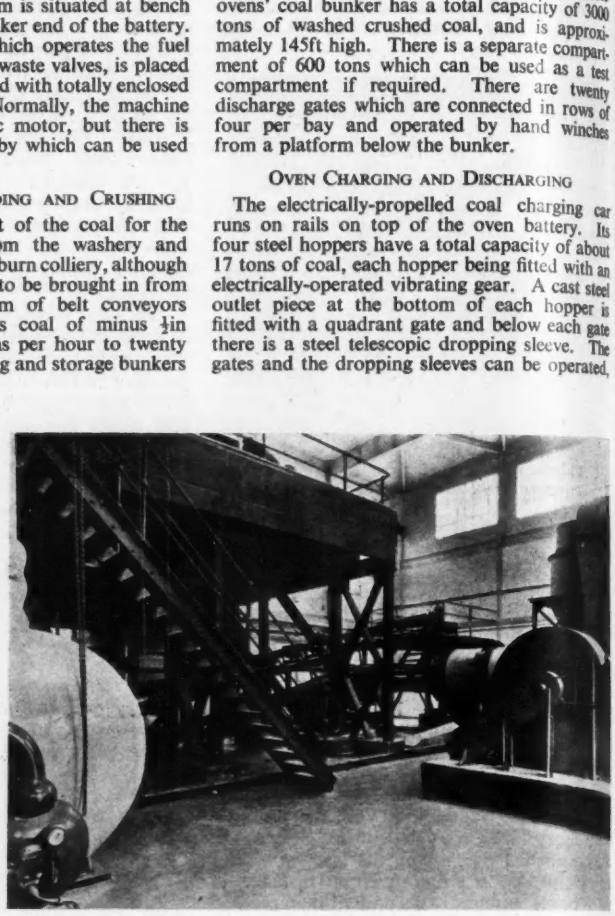
The electrically-propelled coal charging car runs on rails on top of the oven battery. Its four steel hoppers have a total capacity of about 17 tons of coal, each hopper being fitted with an electrically-operated vibrating gear. A cast steel outlet piece at the bottom of each hopper is fitted with a quadrant gate and below each gate there is a steel telescopic dropping sleeve. The gates and the dropping sleeves can be operated by hand levers, independently of each other. An electrically-operated self-landing and delivery hoist is installed at the ovens' coal bunker for elevating coal withdrawn in the levelling operation and returning it to the coal charging car.

When carbonisation is complete the coke is discharged by a pusher machine into a coke quenching car. The pusher machine travels the length of the batteries, levels the charge of coal in the oven, removes and replaces the oven doors on the pusher side and pushes the charge of incandescent coke out of the oven. The machine weighs about 96 tons and runs on rails which are laid on a reinforced concrete foundation. The pushing ram, which is built of structural steel with a cast steel head and supporting shoe, is rack and pinion driven. The pusher machine and the coke guide are connected by a system of electrical interlocks which prevent the operation of the pusher ram until the coke guide is opposite the same oven and is in position to receive the charge. Incidentally, this interlocking system includes a warning lamp signal between the operators of the two machines. One of the photographs reproduced on our inset plate shows the pusher side of the coke oven batteries.

The hot coke discharged from the ovens is received by a quenching car, the steel body of which is 40ft long between the end plates. The car is mounted on a structural steel undercarriage having two four-wheeled bogies for running on a standard gauge track. There are two side discharge doors extending the full length of the car, each of them being separately operated by a compressed air cylinder controlled from the



The basement beneath the coke-oven batteries, showing the arrangement of the cross header pipes which feed fuel gas to the underjet heating system



Interior of the sulphate house, showing one of the centrifugal driers. There are two driers, each having a charge capacity of 800 lb of sulphate

cab of the electric locomotive which hauls the car. The locomotive is designed for a speed of about 10 m.p.h. An electrically-operated door extracting machine with a trailing coke guide removes and replaces the doors on the coke side of the ovens and guides the hot coke over the coke side platform.

The coke quenching station has a brick wind shield and tower rising 100ft above rail level and includes reinforced concrete settling sumps. A 10,000 gallon overhead tank supplies the quenching water to a series of sprays through a hydraulically-operated quick-opening valve which is controlled automatically by the coke quenching car as it enters the station. Two electrically-operated centrifugal pumps deliver water from the pump sump to the quenching tank. Each pump has a capacity of 30,000 gallons of water an hour, and one acts as standby to the other. The pumps, which are operated automatically by a float in the overhead quenching tank, are situated in a concrete well built below ground level to provide a flooded suction. A breeze hoist and grab travelling on an overhead track recovers the breeze from the settling sump and delivers it direct into railway wagons.

An accompanying illustration shows the coke side of the oven batteries.

Coke Handling and Screening

The quenched coke is discharged on to a reinforced concrete inclined coke cooling wharf, which is 160ft long. From there a 36in belt conveyor delivers the coke direct to a primary single-deck vibrating screen, which separates the coke at 2½in and has a capacity of 75 tons an hour. The oversize coke from the primary screen is delivered by chute on to a 42in belt conveyor, which in turn delivers it on to a 42in furnace coke boom loader and lowered into wagons on a rail track close to the secondary screening station. Alternatively, the oversize coke can be fed into a coke cutting machine and reduced in size to −1in. Both conveyors have a handling capacity of 105 tons of furnace coke an hour.

The undersize coke from the primary screen, and also the cut coke from the cutter when in use, passes to a 36in belt conveyor, which delivers at the secondary coke screening station. The secondary screening station, a photograph of which is reproduced herewith, is a steel-framed brick-panelled structure built over six storage hoppers, each of which has a capacity of 30 tons. By passing through the four screens at the secondary station, the coke is graded into sizes of 1in to ¾in, ¾in to ⅜in, ⅜in to ⅛in, and ⅛in to 0in. The hoppers are provided with discharge gates and outlet chutes, so that each grade of coke, apart from breeze, can be delivered over de-breezing screens into rail wagons or road lorries, or to the two weighing and bagging machines on a bagging platform.

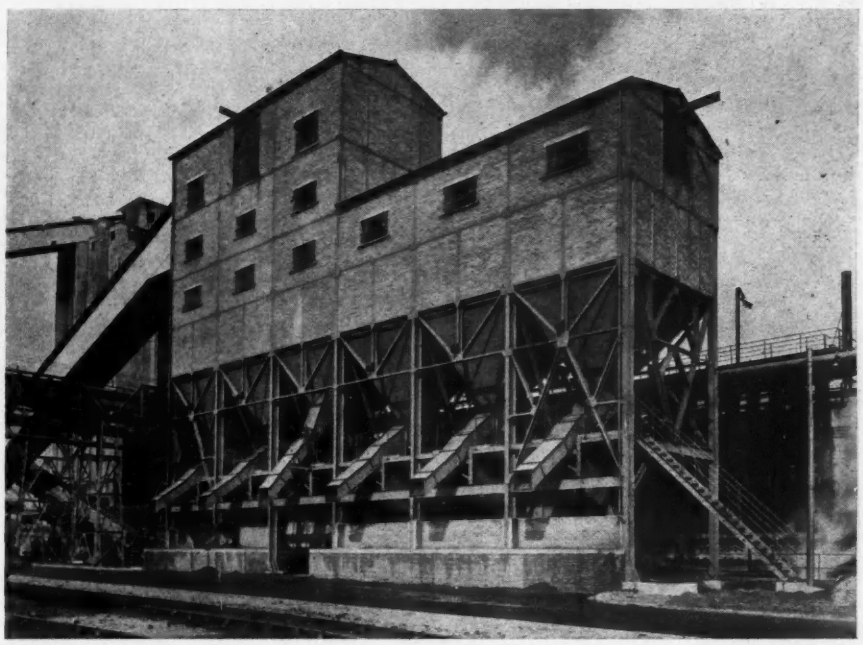
Gas Collecting System

The crude gas leaves the ovens through ascension pipes at both the pusher and the coke sides and passes into the gas collecting mains, which are also on both sides of the batteries. Two bridge pipes, one for each battery, span the batteries at their adjacent ends and connect the pusher and coke side collecting mains. From the centre of each bridge pipe there is an offtake main, and these two offtake mains are joined into a common suction main which spans the coke car track and terminates at the downcomer before the primary cooler. Two ascension pipes are provided for each oven ; they consist of a refractory-lined mild steel standpipe and cast iron return bend with an inspection hole and cast iron cover. Each return bend is fitted with a spray for liquor flushing and with a steam connection for use during the coal charging operation. A hand-operated cast steel liquor-sealed dish valve is provided between each return bend and collecting main.

The collecting mains have liquor sprays placed at every alternate oven, each main being complete with a liquor-sealed bleeder, and four pitch traps are provided to serve the collecting mains. A steel bridge supports the pipes over the batteries. There are two gas pressure regulators to maintain a constant pressure in the collecting mains, and each offtake main has a butterfly valve, which is controlled by a regulator enclosed in a cabin situated on the bridge over the batteries. The return flushing liquor from the coke side collecting mains and the accompanying heavy condensates from the gas flow pass along the suction main and downcomer to the liquor flushing tank.

Gas Cooling and Tar Extraction

The gas passes from the ovens to vertical tubular water-cooled primary coolers which stand on an elevated reinforced concrete structure. There are three coolers, two of which are normally in operation with one as standby, and each cooler is provided with two seal pots to receive the condensed tar and ammoniacal liquor. The space beneath the coolers forms a washroom with showers, &c., for the by-product plant operatives. From the primary coolers the gas is passed by the exhausters to the electro-detarrers. There are two detarrers of 9ft diameter, both of them being of the vertical tube suspended wire electrode design. Normally both detarrers are in operation, but in an emergency either is capable of handling the normal gas load without loss of efficiency. The detarrers are situated on the roof of the building containing the two transformer rectifier sets for operating the detarrers. The arrangement of the detarrers and primary coolers may be seen in the background of one of the photographs reproduced on the art plate.



The secondary coke screening station with ovens battery behind. On the left the gas offtake main leading to the by-product plant can be seen

Ammonia Saturators and Acid Separators

The same illustration shows the ammonia saturators to which the gas passes, through a reheater, from the electro-detarrers. There are two welded steel saturators, 12ft 6in in diameter, supported on structural steel columns. They are designed to produce a large crystal salt. The gas enters through the cracker pipes and bubbles through the sulphuric acid contained in the saturators and passes to separators where any traces of entrained acid are removed. The cracker pipes, and the continuous overflow weirs and piping, are all constructed of Monel metal. Within the saturator a distribution ring admits gas under pressure, which agitates the liquor and crystals and, together with the arrangements whereby the liquor is heated and recirculated, assists the formation of large crystals. The saturators and separators are in the open and stand over a concrete tray sloping to a sump. Both tray and sump are protected with lead and acid-resisting tiles.

Each saturator is provided with a bronze salt ejector for discharging the sulphate produced through the lead and tile-lined sulphate pot to stainless steel crystal separators. There are two separators and the sulphate passes from either of these to the centrifugal driers, the separated mother liquor being returned to the saturators. Two electrically-driven, two-stage air compressors supply the compressed air for use in the sulphate ejector. One is normally in operation and its capacity is sufficient for the plant when it is duplicated in the future.

In the centrifugal driers the large crystal sulphate is washed free of acid and partially dried. There are two suspended self-balancing driers, one of which is normally in operation with the other as standby, each having a charge capacity of about 800 lb of sulphate. The casing, basket and discharge valve are of " Staybrite " steel and a sheath of the same metal protects the spindle. Each centrifuge is driven by an electric motor through a scoop controlled fluid coupling and is fitted with a plough discharge. From the driers the sulphate is fed by a 20in belt conveyor to the sulphate drying and neutralising machine. The sulphate neutraliser is a rotary louvre machine with a capacity of 30 tons a day. The drying air, which is preheated by a low pressure steam tubular heater, is admitted at the feed end. Two centrifugal fans, one inlet and one exhaust, are provided and also two cyclone dust collectors to remove any particles of sulphate carried forward with the exhaust air. The drier is electrically driven through a vee-belt drive and single reduction gearbox and separate motors are provided for each of the fans. A storage hopper of approximately 6 cubic feet capacity provides the ammonium bicarbonate which a vibrating feeder delivers to the feed hopper of the rotary drier to neutralise the salt should this be necessary. An enclosed bucket elevator receives the salt from the drying machine and delivers it to the bagging hopper, beneath which there is an automatic bag-filling and weighing machine. A portable electrically-driven conveyor is provided for loading the bagged sulphate into road vehicles or rail wagons.

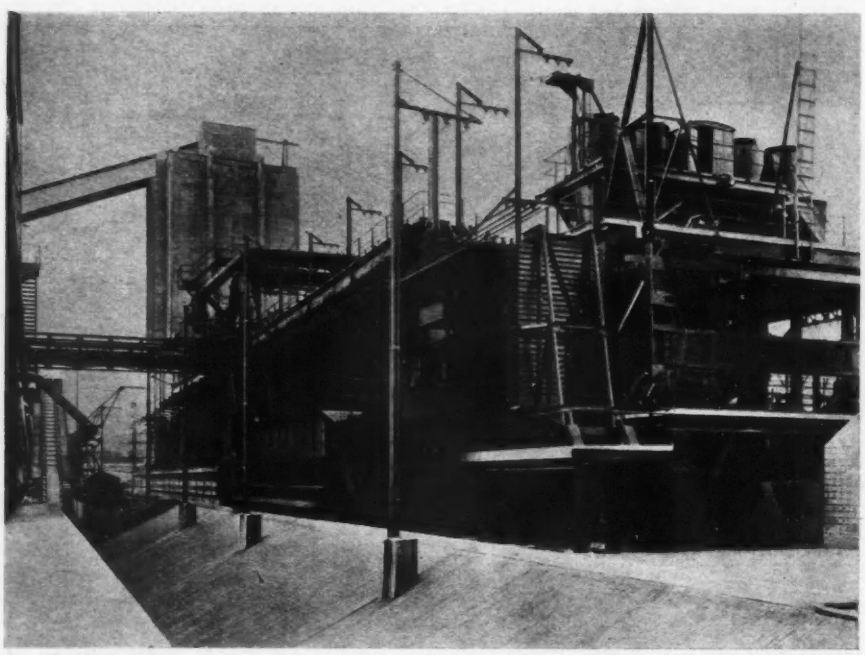
The by-product plant building is subdivided to form the exhauster house, sulphate house and sulphate store. It is a steel-framed brick-panelled building with the external faces of the steelwork brick-enclosed. The exhauster house is large enough to receive an additional exhauster and pumps for the extended plant of the future and is provided with a 3 tons capacity crane with

overload runway. There is an overhead crane of similar capacity in the sulphate house.

Ammonia Liquor, Tar and Acid Services

Reference has already been made to the ammonia liquor circulating system to the ascension pipes and collecting mains. The liquor flushing and separating tank has a 45 deg. slope at the outlet end and a decanting capacity of 45,000 gallons. Two scraper conveyors continuously remove the sludge which is discharged from steam heated outlet hoppers through sludge valves, and the tar overflows into a 5000 gallon receiving tank, the liquor being decanted into a receiving tank of 10,000 gallons capacity.

A reinforced concrete condensate drain pit of 1000 gallons capacity receives the drainage from the exhausters and detarrers and the overflows from the tar and ammonia liquor storage tanks. Tar and liquor are transferred from this drain pit to the flushing and separating tank by one of three steam-driven duplex pumps. The second duplex pump transfers tar from the tar collecting tank to the tar storage tank, of 135,000 gallons capacity, and to tank wagons as required. The third duplex pump acts as a common standby. A lead-lined, cast iron mother liquor tank receives the overflow from the liquor circulating tank and the drains from the concrete tray beneath the saturators. Mother liquor is delivered from this tank by a bronze ejector. Acid for the saturators is stored in three tanks, each of 5500 gallons capacity. Either of two pumps delivers the acid to an elevated tank from which it is fed to the saturators.



The coke side of the batteries. In the immediate foreground is the coke wharf, with, on the left, the coke wharf conveyor leading to the primary coke screening station

Benzole Recovery

After leaving the saturators and acid separators, the gas passes through a final cooler, which is about 80ft in height, where it is cooled prior to benzole extraction. From the cooler the gas goes on, through a water separator to two benzole scrubbers wherein it travels in series in an upward direction, meeting a downward travelling stream of wash oil which absorbs the crude benzole. The scrubbers are 95ft high and provided with wooden hurdles and an oil-distributing device. These parts of the plant are illustrated in the art plate. After leaving the scrubbers, either of which can be by-passed, the gas passes through an oil separator to the three lift spiral-guided holder, the capacity of which is 500,000 cubic feet.

The wash oil from the scrubbers, enriched with benzole, is passed through two vertical tube vapour-to-oil heat exchangers, normally working in series but each capable of being by-passed. In these exchangers, heat is transferred from the crude benzole vapours leaving the still to the "benzolised" wash oil. The enriched wash oil is then steam heated in either of two final heaters and enters a cast iron wash oil still. The still, which is 5ft in diameter, deals with the whole of the wash oil and has a series of fourteen trays where the crude benzole is removed by intimate contact with steam. A small portion of the "debenzolised" wash oil is passed through a wash oil purifier for conditioning, and the hot oil from the still is pumped through a wash oil cooler before recirculation to the scrubbers. The wash oil cooler is arranged so that any of its banks of piping can be by-passed and steamed out if necessary. The crude benzole vapour passes from the still through the vapour-to-oil heat exchanger to the crude benzole coolers. From the cooler the crude benzole passes through a separator and either to storage or, through a lifter, to the CS_2 still. The CS_2 still is of cast iron and consists of a bottom section with thirteen stripping sections and an upper section with twenty-seven rectifying sections, the whole being surmounted by a reflux chamber. In the still, CS_2 is removed from the benzole, which is then cooled and passed to storage. The CS_2 from the still passes through a condenser to a decanter from which a portion is returned to the reflux chamber and the remainder flows to the drumming tank.

Water Cooling and Recirculating Plant

Raw water for the Fishburn plant is drawn from the existing reservoir by either of two centrifugal pumps of 30,000 gallons per hour capacity. The bulk of the water used on the plant is recirculated, make-up being supplied from the raw water pumps after passing through a treatment plant. An induced draught cooling tower is provided to deal with two separate circuits, there being two cells for water used on the primary coolers and miscellaneous duties, and two for water which comes into direct contact with the gas in the final cooler. A decanting tank is arranged in the direct cooler circuit to intercept any tar which may be entrained in the water leaving the final cooler.

Five motor-driven centrifugal pumps are supplied for recirculating the water, there being two in the primary circuit, of 60,000 gallons per hour capacity, and three in the final circuit of 25,000 gallons per hour capacity. In each case the recooled water is pumped to the apparatus from the respective cold well below the cells. Warm water from the primary coolers returns by gravity to the cooling tower but in the final cooler circuit a pump is used after the decanting tank to deliver the warm water to the tower.

Conclusion

This description has been confined to the installations for which Woodall-Duckham Construction Company, Ltd., was responsible. The remaining installations were provided by contracts let separately by the National Coal Board. They include the boiler plant supplied by Daniel Adamson and Co., Ltd.; gas producer and cleaning plant by Gibbons Heurtey, Ltd.; gas booster station by Belliss and Morcom, Ltd., and a dry purification plant erected by Newton Chambers and Co., Ltd.

Main Sub-Contractors

The following were the principal sub-contractors to Woodall-Duckham Construction Company, Ltd.: blending and storage bunkers, A. Monk and Co., Ltd.; oven machines, Wellman Smith Owen Engineering Corporation, Ltd.; water cooling tower, L. G. Mouchel and Partners, Ltd., and A Monk and Co., Ltd.; coal and coke conveyors, W. J. Jenkins and Co., Ltd.; coke screens, Fraser and Chalmers Engineering Works and W. J. Jenkins and Co., Ltd.; coal crushers, British Jeffrey Diamond, Ltd.; breeze hoist, Vaughan Crane Company, Ltd.; coke cutting machine, Robert Cort and Son, Ltd.; pumps, British LaBour Pump Company, Ltd., Joseph Evans and Sons (Wolverhampton), Ltd., Gwynnes Pumps, Ltd., and E. N. Mackley and Co., Ltd.; gas holder and electro-detarrers, Whessoe, Ltd.; exhausters, British Thomson-Houston Company Ltd.; centrifugal driers, Watson, Laidlaw and Co., Ltd.; sulphate neutralising machine, Dunford and Elliot (Sheffield), Ltd.; gas regulators and compressors, Reavell and Co., Ltd.; electric locomotive, Robert Stephenson and Hawthorns, Ltd.; electrical installations, Marsh Bros., Ltd.; rail tracks, Thomas Summerson and Son, Ltd.; site preparation, John Gill Contractors, Ltd.

Steam Turbine Oil

The increases in operating steam pressures and temperatures has enabled the size of turbine machinery to be reduced and, by the adoption of new manufacturing techniques and materials, a reduction has been effected in the size of reduction gearing. However, the tooth loading of the new gears was too high for the existing steam turbine oils and the Admiralty approached the oil industry with the problem of producing a suitable lubricant. After extensive research on the problem, C. C. Wakefield and Co., Ltd., has devised, it is claimed, a lubricant which satisfies the Admiralty specification of steam turbine oils and also meets the new gearing conditions and has been proved in the main turbines of a destroyer in tests lasting for a year and involving over 1000 hours' steaming.

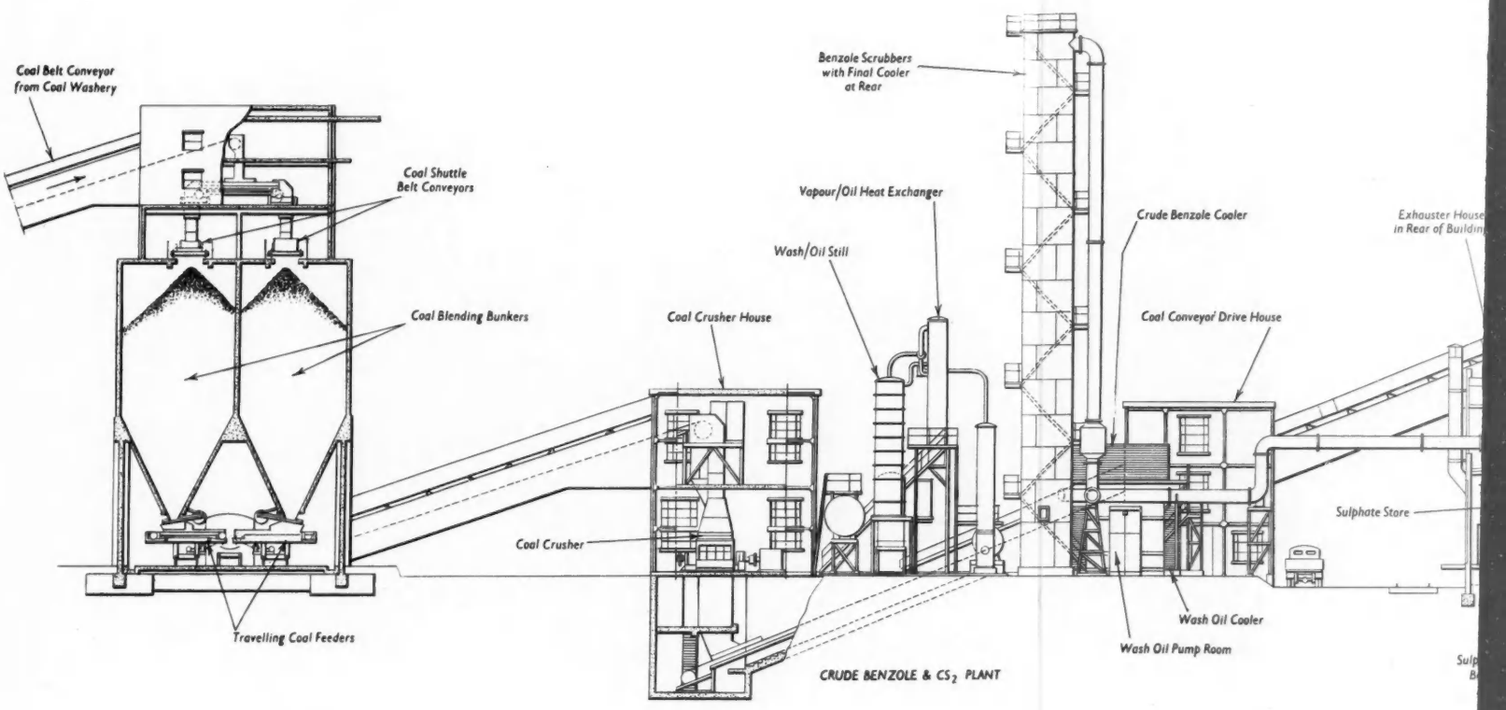
This new "Perfecto LC" steam turbine oil meets the requirements of the British Admiralty turbine oil specification OM.100 and includes a load-carrying additive which does not affect its demulsibility, oxidation resistance or anti-corrosion properties of the oil. The following table gives the results of tests on an Institution of Automobile Engineers' 3½in gear test machine with an oil temperature of 70 deg. Cent.

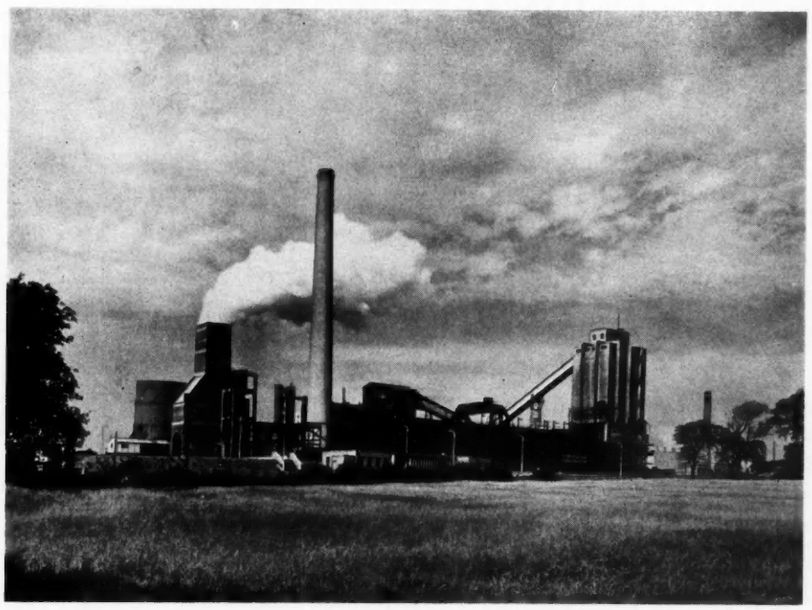
Scuffing Load in Pounds

Lubricant	Gear material EN 34			Gear material EN 36		
	2000 r.p.m.	4000 r.p.m.	6000 r.p.m.	2000 r.p.m.	4000 r.p.m.	6000 r.p.m.
Normal OM.100 ...	60	40	25	45	35	25
"Perfecto LC" ...	125	105	100	120	110	95

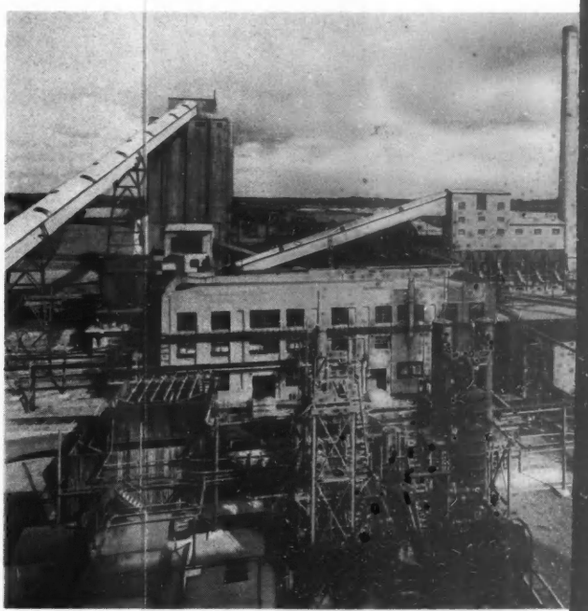
In subsequent full-scale tests on naval reduction gearing of advanced design, scuffing of the gear teeth occurred at 65 per cent of full power torque, equivalent to a tooth loading of 1500 lb per inch of contact line, when using an OM.100 turbine oil. No scuffing occurred, however, at 130 per cent full-load torque, or twice the previous tooth loading, when "Perfecto LC" was used. It is claimed that the oil has no effect on normal materials used in the construction of modern steam turbines, and that a copper staining inhibitor prevents any attack by the load-carrying additive on copper and copper alloys at high temperatures.

COAL CARBONISATIO



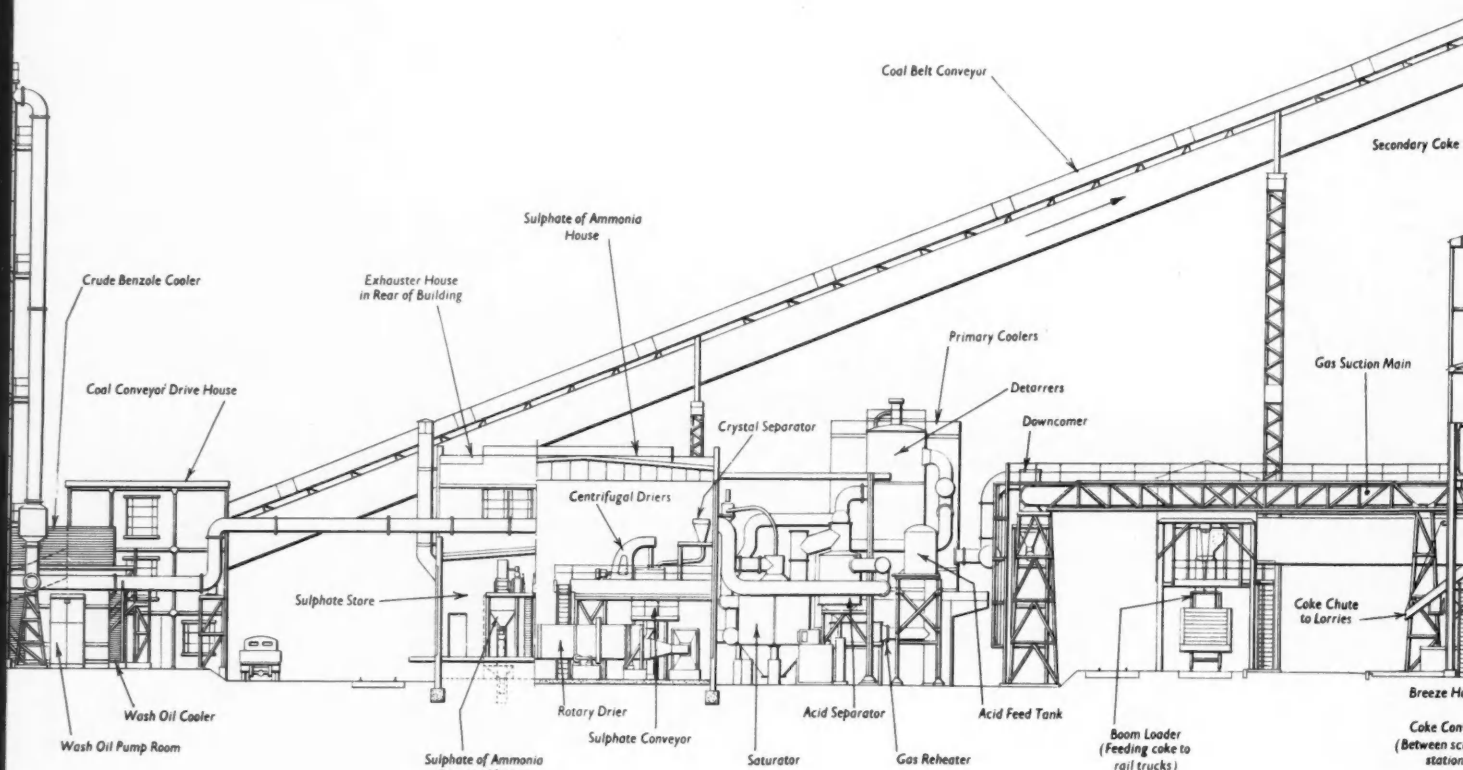


The plant has a carbonising capacity of 1000 tons of coal per day, which will come mainly from Fishburn Colliery

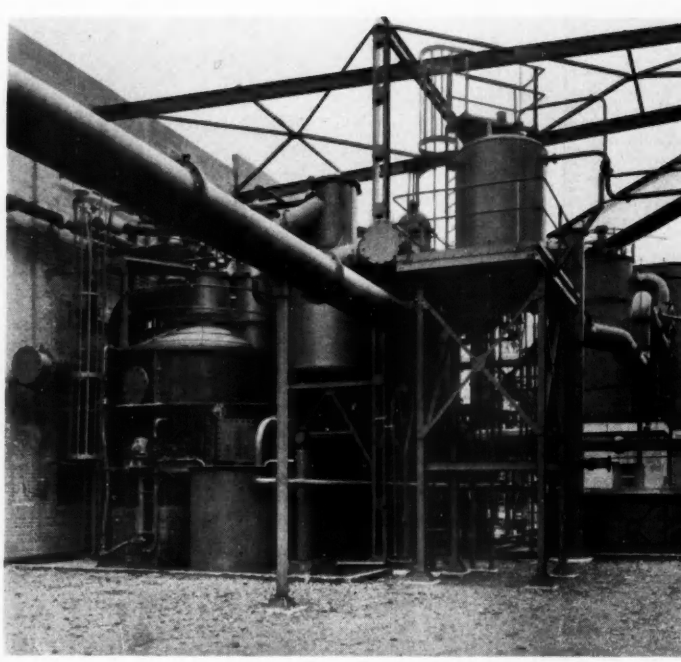


The crude benzole plant, exhauster and sulphate house, final cooler

L CARBONISATION PLANT AT FISHBURN, CO. DURH



zole plant, exhauster and sulphate house, final cooler and benzole scrubbers



The ammonia saturators and, in the background, the electro-detarrers and p

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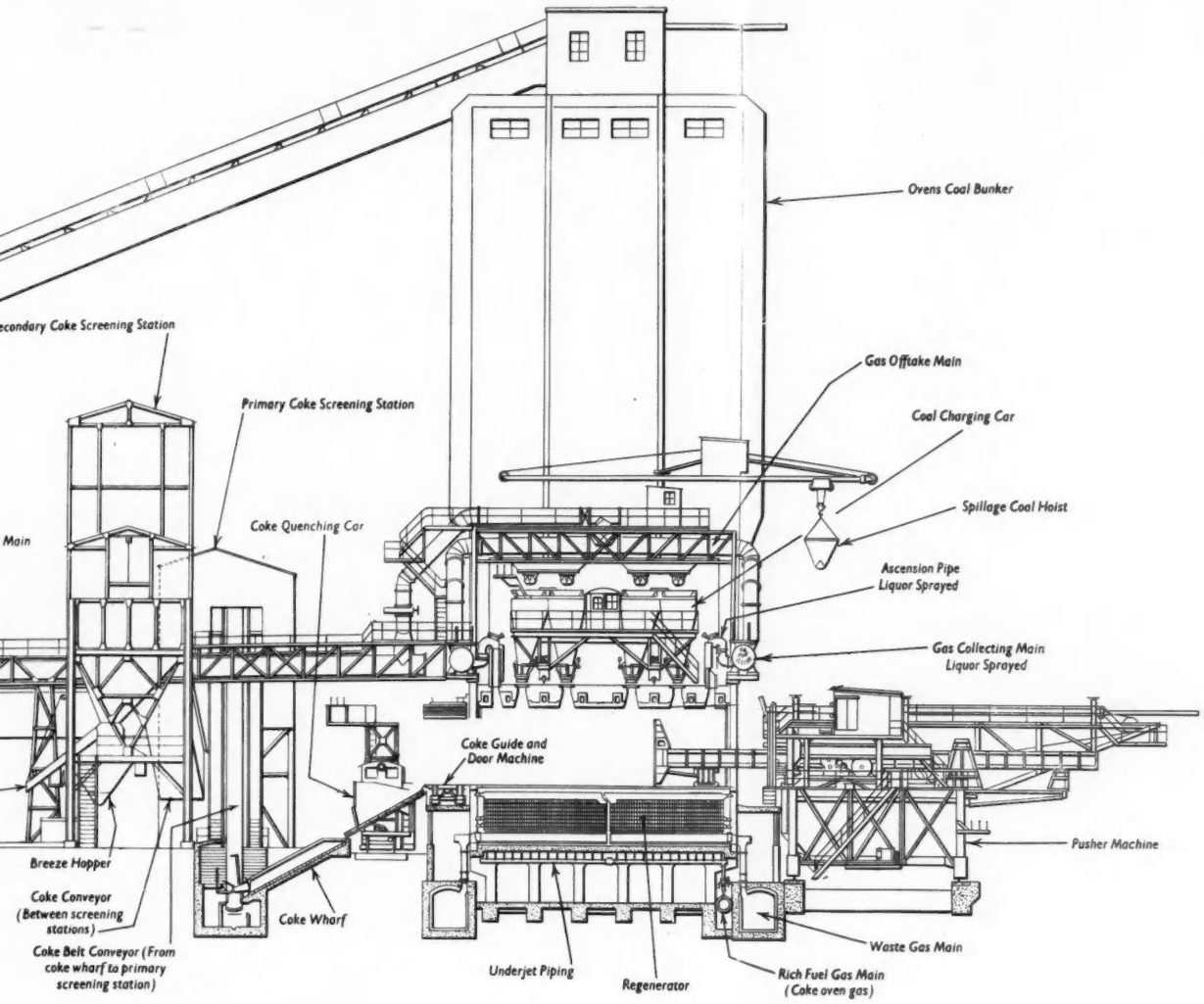
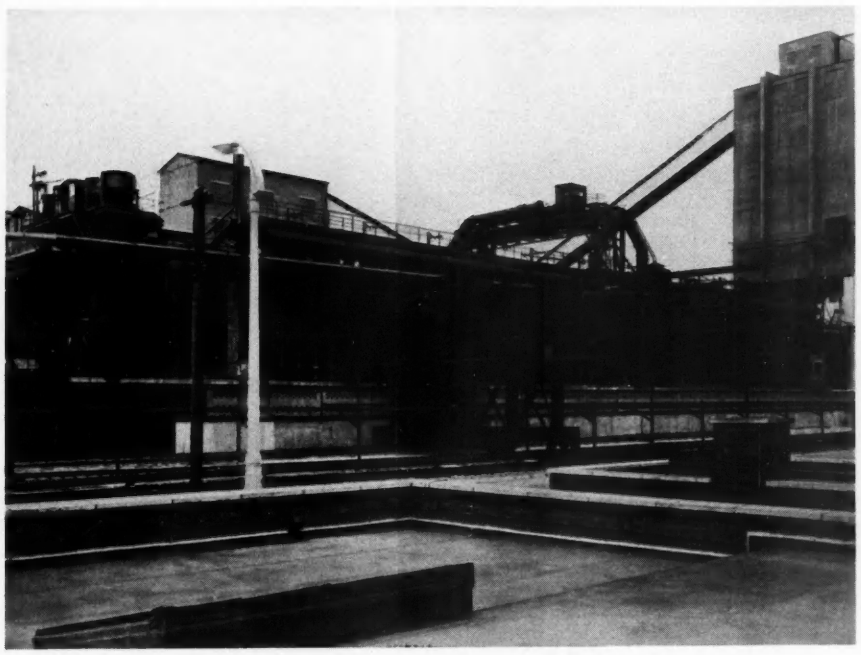


rrers and primary coolers



Pusher side of the coke oven batteries. The building in the background is the secondary coke screening station

Engineering and Education*

By R. H. GRUNDY, M.I.C.E., M.I.Mech.E., M.I.N.A.

IN the past a classical training allied with integrity of character produced the trained mind and broad outlook which was able to lead without a knowledge of the details of the work being controlled. At the present time, the specialisation produced by the pressure of accumulated knowledge calls in addition for leadership which must have personal knowledge of details obtained by an apprenticeship (using the word in its widest sense), because ignorance of science, economics and engineering can now cause errors of judgment whose consequences are vast compared with the localised sphere of such mistakes in the past.

In the future the executive engineer must no longer work as he frequently does at present, under some over-riding financial administrator or legal functionary whose ignorance of engineering principles is abysmal, in brief, the engineer must join the board of directors. One of the causes of the rapid increase in the industrial power of the United States of America is the increasing use of the engineer in the top level of management, beyond the usual limits of development and design. On the Continent the status of the professional engineer is surpassing that of the older professions, and until the engineer attains this pre-eminence in this country parents will continue to encourage their sons to enter the non-productive but better paid professions. The engineer, with suitable training, can acquire administrative skill more readily than the administrator can acquire technical knowledge. But to be worthy of his administrative responsibilities the engineer must first ensure his mastery of the English language and be able to speak and write it with clarity and persuasive power ; he must become more articulate than he is at present.

But who shall teach English language and literature in the manner required for our future engineers in the New Industrial Revolution, on the threshold of which we now stand ? Certainly not the present type of teacher who follows the usual classical education, an education which is a vocational training for entry to preparatory and public school teaching, the Church, Law, Diplomacy and much of the Civil Service. He has not the necessary scientific background, nor the necessary faith and hope for the future, and lacks that forward view which is the quest of the unknown in contradiction to obsession with the past, an obsession which seems to make its devotees intellectual refugees from their own age ; we cannot walk backwards into the future. This future, in an industrial age, in which change is the order of the day, implies continual training in new techniques, and an ever-widening search on the boundaries of knowledge. Judging from the literary output of the present day, satisfactory methods do not appear to have been devised to impart to the classical student the spirit of science, that spirit which embraces an objective love of truth, an intellectual honesty, and a freedom from prejudice.

It is common for the classically educated to point the finger of scorn at the illiterate scientist (I quote this now very popular adjective from the national Press) and at the engineer and to decry their ignorance of the arts. I think, however, that very many engineers and scientists would admit their ignorance and would regret that they had not more time to devote to what are called, for want of a better term, cultural subjects ; but it is rare to find a man trained in the classics recognising his ignorance of science. Furthermore, surely culture is measured by the level of the artistic and recreative social activity of a community rather than by its knowledge of Latin and Greek.

I cannot over-emphasise the need for a broad education to form the foundation for technical training and the beginnings of this general education must be obtained during school days. The importance of a secondary education in which the humanistic and scientific sides were welded together for some years before the sixth form was emphasised by the Headmaster of Eton at the recent British Association meeting in Liverpool. He advocated such a course for the education of the future, to overcome the division between the present executive civil servant and the scientist, but it is my opinion that such a training alone will still be insufficient to bridge the gap. There is therefore all the more need for the school teachers who provide this foundation as secondary education, to have a broad training themselves and to inculcate in their charges the two most important intellectual virtues, clarity of thought and intellectual curiosity.

The circle of prep-school, public or secondary school, university, and then back to school again as a teacher must be broken by at least a two years' interval in commerce and industry or residence abroad in order to learn how the world lives outside educational circles. As a result of the present " inbreeding," schoolmasters tend to encourage pupils to study in their university courses subjects they have preferred themselves, and naturally engineering subjects do not come into this category. This deficiency must be overcome by wider advertisement of engineering careers and by offering for such careers better rewards as compared with the fruits of commercial activities.

The approximate distribution, in round percentage numbers for the three years 1948–51 of full-time men and women students in universities (65,831 men and 19,483 women) were arts forty-three, pure science twenty, medicine of all kinds twenty-two, technology twelve, agriculture three, and may be taken as a representative trend which shows that nearly half the university student population is taking arts subjects ; the corresponding figure for 1938–39 was 44·8 per cent. Unless large numbers of these students in the coming years are deflected from arts to science and engineering (as they are now naturally turning in Western Germany) the standard of living in the country will fall, because productivity depends upon action, not upon talking and writing about it.

Previous to the implementation of the 1944 Education Act, many students came to technical colleges because they could not obtain by any other means the higher education for which they were fitted. These students now go to the universities, and I would be the last person to have it otherwise, but unless the technical colleges have high-grade work they cannot survive. They should therefore become responsible for teaching the higher-grade technologies, not only to their own students who have obtained the Higher National Certificate, but to university graduates as well. The universities should concentrate on a broad educational curriculum which can be taught nowhere else with such success.

In 1952 the Director-General of the Federation of British Industries, quoting from the report of the universities and industry productivity team, emphasised their recommendation that immediate attention should be given to the provision as rapidly as possible of extended facilities for preparing a large number of young men for industry, giving them a broad general education on a full-time basis with a technical standard at least as high as that of the Higher National Certificate. This recommendation has again been repeated in the 1954 Industrial Engineering Productivity Report, and the National Certificate scheme, which differs most from schemes of technical education in America (where good engineering is accepted as one of the founts of prosperity), has been quoted as the most outstandingly successful in Britain. It is urged that future and rapid development of post-national industrial engineering studies should be provided, with support for day release from industry for men who have passed out of apprenticeship. I have seen little practical result of such recommendations ; nor is there likely to be any until employers are educated to the desirability of such instruction, and the necessary finance found by a Government and by local authorities whose present policies are intense economy in all educational matters.

Nevertheless, the growing importance of technical education in Britain is gradually being appreciated, as shown by the spate of White Papers and the endless discussion regarding the relative places of universities and technical colleges in technological instruction. No one qualified to discuss the matter will deny that the university is the proper place to teach fundamental knowledge and by original investigation to open up new avenues of research. All who can benefit by such an education should receive it, and all who have the flair for research should be trained for it.

The number of research workers required by industry is small compared with the number of university graduates required for development and executive posts, for these the standard of an Ordinary Pass Degree in technical education is sufficient before specialisation takes place. These men and women, required in their thousands per year, must afterwards be trained in the specialised technological theories and skills which are growing each year and which are unsuitable to be included in the general curriculum of the university. Where is training to be undertaken if not at the larger colleges of technology ?

Such work would keep the senior teaching staff alert and up to date ; for unless there is advanced work in a college there is no inducement for the best brains to teach in that college ; the mediocre teacher teaches the mediocre student and the standard steadily falls.

When it is realised that there are only twenty degree-granting universities in Britain, compared with more than 200 large and medium-sized technical colleges, it will be appreciated that the universities could not cope with the thousands of young men who are required for the future industrial revolution of this country, irrespective of the question whether the industrial type of work envisaged is suitable for the university curriculum or whether it is desirable that all the country's highest intelligence should pass through the university channel.† How is the deficiency to be met ? First of all the large colleges must be freed from the present millstone of local education authority control by the appointment of truly independent college governing bodies, a system which is already in existence with some colleges and should be extended to the remainder. The finance of these self-governing colleges is provided mainly by the Government and is therefore independent of the local rates and the penurious idealogy of the ratepayer. It is therefore free from the present stranglehold of local political expediency, which advertises education as a political plank during municipal elections and as regularly applies annual and arbitrary cuts upon development. The grants to these technical colleges must be increased so that not only can the technical equipment of the colleges be expanded to the limits required by the urgent need for technological education, but the financial provision must be sufficient to enable the social and cultural life of the technical college to be developed and made suitable, not only for the young students of sixteen to twenty-one, but also for the older and more mature man of twenty-two to twenty-five years who is completing his specialised technical training or who has returned to college for a refresher course.

The extension of technical education by the provision of colleges worthy of their purpose will not be sufficient in itself ; the human material must be forthcoming. There must be a continual flow of suitable students, the university contribution which I have mentioned is only one stream whose size must inevitably be limited by its high quality ; the other contributory stream, via the Higher National Certificate scheme, must be enlarged until it is great enough for all the requirements of industry. This can be done by inducing boys at public and secondary grammar schools to take up engineering as a career, a man-size and satisfying job. But success in this will only come when the ultimate rewards of professional engineers are comparable with those in other professions and with the emoluments of the business and financial executive.

* Liverpool Engineering Society. October 13th. Presidential Address. Extracts.

† Some large organisations are recruiting student apprentices from public schoolboys who hold a General Certificate of Education at Advanced Level.

Radiotherapy Equipment at the Christie Hospital, Manchester

New equipment for radiotherapy at the Christie Hospital and Holt Radium Institute, Manchester, was demonstrated to the Press on Thursday, November 11th. Three installations were seen during our visit: first, a 300kV "Resomax" set, which is a modern development of the orthodox X-ray equipment; secondly, a 4MeV travelling-wave linear accelerator; and thirdly, a 20MeV betatron. The two latter machines are representative of the most advanced schools of thought and practice in radiotherapy, and it is with them that this article is mainly concerned.

ON Thursday, November 11th, we visited Manchester to see newly installed radiotherapy equipment at the Christie Hospital and Holt Radium Institute, which has a long history as a leading centre for the treatment of cancer. For many years the Christie Hospital has used, in its normal therapy department, a quantity of Metropolitan-Vickers X-ray apparatus, and much of the present routine clinical treatment is carried out with the help of four pre-war 250kV equipments and one 500kV equipment. Now this installation has been augmented by a 300kV "Resomax" set, made by Newton Victor, Ltd., a subsidiary of Metropolitan-Vickers Electrical Company, Ltd.

Greatly increased facilities, particularly for research and advanced work, have recently been acquired in a new building provided by the Medical Research Council and equipped with what can fairly be described as a unique collection of apparatus for radiotherapy. This plant includes a second "Resomax 300" set for control purposes and two machines of new design—a 4MeV travelling-wave linear accelerator and a 20MeV betatron.

Our tour of the new installations was preceded by a short introductory talk by Dr. Ralston Paterson, the director of the radiotherapy department at the Christie Hospital, who outlined the position held by radiotherapy in the treatment of deep-seated tumours. He pointed out that over the past quarter of a century radiotherapy had grown to become the most widely used method for the treatment of cancers, being applicable to many, but by no means all, forms of cancer. He went on to say that of all the patients treated, to-day, about 40 per cent were cured; the new machines (described here) did not offer any prospects of miraculous cures of all cancers, although it was confidently hoped that the proportion of cures would be increased by their use.

The main advantages of X-rays generated at high voltages may be summarised as follows:—

1. There is greater penetration of the radiation making it easier to deliver an adequate dose at a depth.

2. The maximum dose is produced not on the surface as at 250kV, but some distance below, thus reducing undesirable skin effects; for 4,000,000V X-rays the maximum is at about 1cm below the surface, while for 20,000,000V it is 4cm deep.

3. The amount of scattered radiation, and, hence, the dose received outside the useful beam, is greatly reduced.

4. Below 1,000,000V, bones absorb X-rays much more than does normal tissue (which is why bones are revealed on X-ray pictures), whereas above 1,000,000V bone and soft tissue absorb X-rays nearly equally, a very real advantage in radiotherapy.

On the other hand, there are difficulties attending the use of radiation of extremely high energy: for example, the increased penetration through tissue (itself an advantage) may cause trouble because of the increased exit dose—that is, the dose inflicted on the skin at the point where the beam leaves the patient's body.

"Resomax 300"

The "Resomax 300" equipment is a logical up-to-date development of the orthodox form of X-ray equipment in which the full accelerating voltage is applied directly across the accelerating tube. As the youngest of an established family of machines its performance may be predicted with some confidence; it may be regarded, without disparagement, as a "bread-and-butter" equipment compared with the newer and higher voltage machines described below.

By making use of a resonant high-voltage transformer, the "Resomax 300" set is more efficient than earlier sets and the elimination of the iron transformer core is responsible for a considerable reduction in size and weight. This design also enables the specially developed multi-section X-ray tube to be mounted coaxially inside the transformer (the entire tube head assembly being oil-immersed), while the tube target, at earth potential, projects about 30in from the main tank. A clear field is thus provided for angulation and direction of the X-ray beam and for ease of setting-up of the patient. Because the target is at earth potential cooling can be by mains water with complete freedom from problems of electrical insulation.

The X-ray tube head is shockproof and is supported on a single pillar stand free of projections, thus giving an unobstructed floor area for manœuvring the treatment table. A 72in vertical movement and a 370 deg. angulation of the tube head are provided by motor drive under push-button control. There is also manual control of tube-head rotation in the vertical plane. This universal range of tube movements and their clear scaling simplify operation and the reproduction of all treatment positions. Operation of the set is effected from a control unit which, like the X-ray equipment itself, is finished in cream cellulose enamel.

4MeV Linear Accelerator

Compared with the more orthodox "Resomax 300" the 4MeV linear accelerator represents an advance towards comparatively unexplored ground. However, in using the new equipment it is likely that there will be few additional problems in dose measurement and treatment planning. Bearing in mind that a similar Metropolitan-Vickers equipment, but operating at 8MeV, has been in use for the treatment of patients at Hammersmith Hospital, London, since August, 1953, it is to be expected that the new 4MeV equipment may soon be applied for routine treatment.

The 4MeV travelling-wave linear accelerator has been given the name "Orthotron" (literally "straight-line accelerator"). It operates on the same principle as does the 8MeV Hammersmith installation, which was the first of its kind in the world to be designed and used specially for clinical purposes, and which was described in our issue of Oct. 30, 1953, page 554.

Briefly, in the "Orthotron" (Fig. 1) the electrons are accelerated by the action of an axial electric field associated with a radio wave propagated inside a hollow metallic tube. As a very crude analogy, the electrons may be considered to "ride" on the radio wave in much the same way as a surf rider may ride on a sea wave. By the introduction of metallic discs (or irises) into the guide, it is possible to control the phase velocity of the wave and ensure that the wave and the electrons accelerated by it travel at the same speed. Such a guide is usually referred to as a "corrugated waveguide" (*L*, Fig. 1).

By varying the diameter of the central iris hole and that of the guide itself, the wave velocity and accelerating field are controlled. It can be arranged that at the input end of such a guide the wave velocity is, say, 0·4 times the velocity of light, so that electrons injected from a gun operating at 40kV to 50kV will have the same velocity as the wave. If now the diameters of the iris hole and of the guide are varied progressively along the length of the guide, the wave

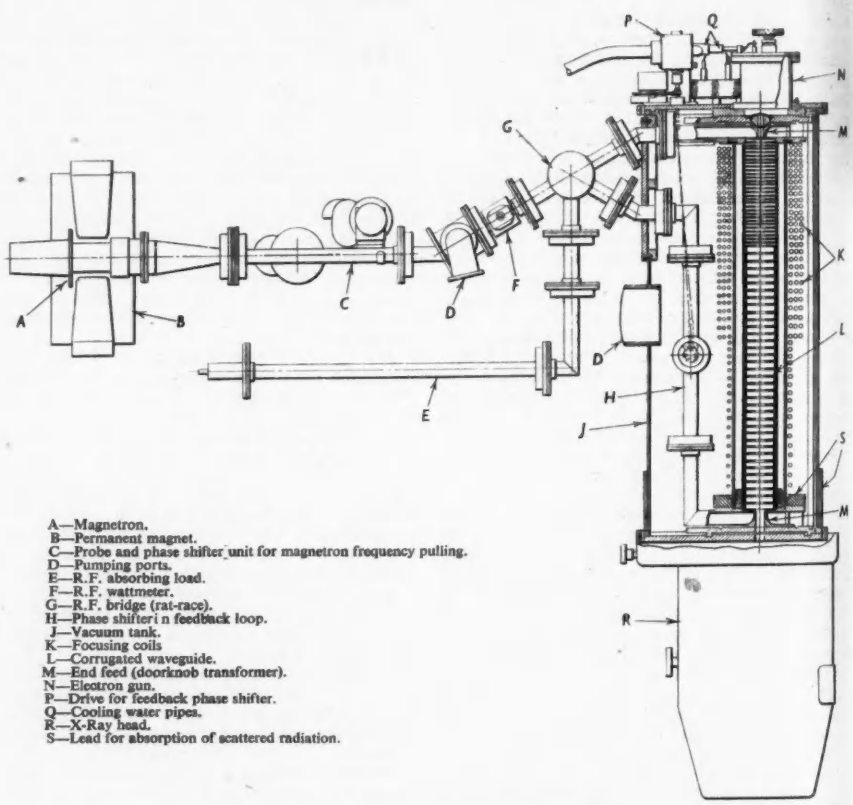


Fig. 1—Cross section of 4MeV "Orthotron"

velocity can be increased towards the velocity of light and the electrons collected by the wave will be accelerated. At energies greater than about 1MeV an electron has a velocity only slightly less than that of light, and thereafter it acquires energy from the wave by increase in mass rather than by increase in velocity ; thus, in the later stages of acceleration the wave velocity needs only slight variation or, in practice, may even be kept constant.

In a guide of this kind there is, besides the axial accelerating field, a radial electric field and a circumferential magnetic field, the resultant effect of which under normal conditions tends to disperse the beam of electrons. A steady axial magnetic field is therefore required to compensate for this effect by a focusing action. Such a field is readily provided by solenoids surrounding the accelerator guide (*K*, Fig. 1).

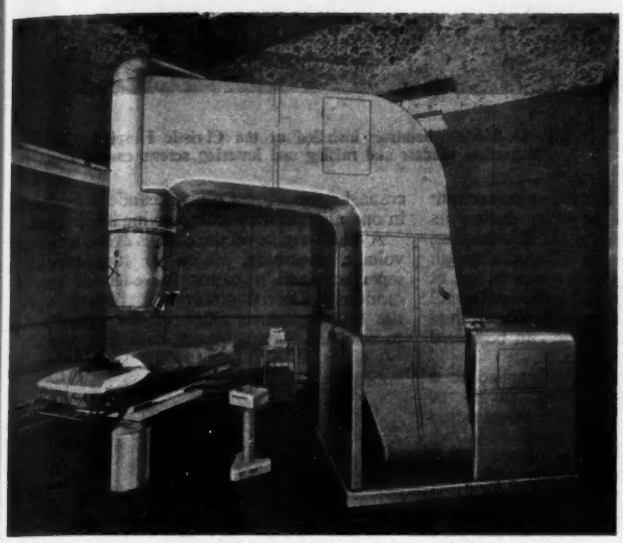


Fig. 2—4MeV " Orthotron " for radiotherapy at Christie Hospital, Manchester. The X-ray equipment and the table can be adjusted to obtain the desired entry and exit points of the beam

To obtain the high electron energies required, high fields in the corrugated waveguide (of the order of 30kV/cm to 40kV/cm) and hence very large radio power fluxes of the order of megawatts are necessary. Such considerations enforce pulse operation of the equipment, and, since the free-space wavelength may conveniently be 10cm, operation becomes similar to that of pulsed radar equipment. The r.f. source is a 2MW magnetron operating at a pulse length of 2 microseconds and recurrent rates up to 500 pulses per second, giving a mean power output up to 2kW.

To increase the peak power flux in the accelerator guide to a value approaching 4MW use is made of a system of r.f. power feedback first suggested by Harvie and Mullett.* Referring to Fig. 1, residual power from the output end of the corrugated waveguide is fed back through a loop via a phase shifter *H*, to be recombined in suitable phase relationship with the incoming power to give increased power flux in the accelerator. This recombination takes place in the r.f. bridge or " rat-race" (*G*). The bridge has unity ratio and when the losses round the whole feedback loop are 3 db the power amplification ratio is 2.

Adjustable diaphragms in the X-ray head (Fig. 5) define the beam. These diaphragms provide for continuous adjustment of field size and are supported on arms hinged at the target. It is thus arranged that the edges of the diaphragms remain parallel to the edge of the X-ray beam and that oblique absorption in the diaphragm edges is reduced to a minimum. The diaphragms extend more than half-way from the target to the skin, thereby ensuring that the penumbra is no wider than the diameter of the focal spot, about 5mm. At the same time, the head is compact, especially at the end near the patient, which facilitates the setting-up of glancing fields. The diaphragms can be adjusted to correspond to field sizes ranging from 4cm by 4cm up to 25cm by 30cm, and the beam is limited in diameter to 31cm at 1m. When circular fields are required, suitable diaphragms pierced by a conical hole are inserted into the jaws formed by the outer diaphragms.

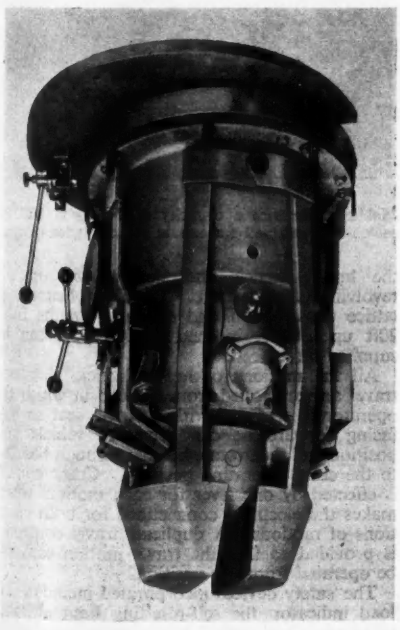


Fig. 3—X-ray head of the 4MeV " Orthotron "

A view of the finished installation is reproduced in Fig. 2. To give adequate room for setting-up the patient, the accelerator is arranged to overhang its support by 6ft. Used in conjunction with a couch with movements complementary to those of the machine, it is easy to set up patients quickly and accurately.

The mounting is arranged so that the machine can be moved to any angle required on a 135 deg. arc lying in a vertical plane and centred about the normal treatment position for the patient. The axis of rotation coincides with the treatment point 100cm from the target, a convenient arrangement for setting-up a 100cm target-skin or target-tumour distance as required.

In the interests of simplicity the controls are arranged in groups. The controls used for setting-up the patient are mounted on a pedestal in the treatment room. Those used by the radiographer are mounted on the sloping panel of the control desk ; those required by the technician in setting-up the equipment are in a well covered by a sliding panel which forms a flat top to the desk.

An important point is the provision of means for switching off the equipment after a predetermined dose has been administered ; this effect is achieved by ionisation chambers in the X-ray head, in conjunction with electronic circuits in the control desk. There are also the usual facilities for ending the dose either manually or by an automatic timer. Separate meters indicate the dose rate and the total dose given.

* *Proc. Phys. Soc. B*, 62, 1940, page 270

When the equipment is operated at 4MeV it can produce an unfiltered X-ray beam output of 330 röntgens per minute at 1m from the X-ray target. After the insertion of a suitable filter to provide a uniform beam over the wide area covered with the diaphragms fully open, this means a maximum output of about 200 röntgens per minute. In practice, it is found very convenient to treat at a rate of 100 röntgens per minute, which enables the equipment to be operated well within its capabilities, with consequent increase in the life of some of the more important valves.

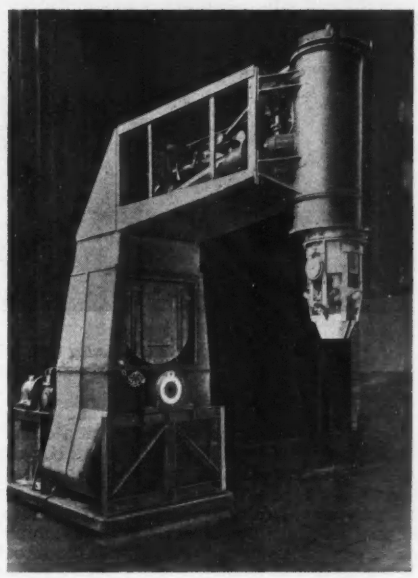


Fig. 4—4MeV " Orthotron " under construction. The X-ray head is fitted below the cylindrical vacuum chamber which contains the corrugated waveguide and focusing coils. The magnetron and waveguide components are in the horizontal framework

During a tour of part of the Metropolitan-Vickers research laboratories after the visit to the Christie Hospital, we saw three 4MeV " Orthotrons " under construction. One of the machines is illustrated in Fig. 4, which shows the X-ray head fitted to the bottom of the cylindrical vacuum chamber, which houses the corrugated waveguide and the water-cooled focusing coils. The horizontal framework carries the waveguide components and the magnetron, the general arrangement of which is outlined in Fig. 1. The pumping equipment and driving mechanism are carried in and behind the vertical member, which, as shown by Fig. 3, is mounted in trunnions and is equipped with counterweights.

Quick replacement of certain important components can be effected. For example, by making use of a waveguide window, the magnetron valve can be replaced without destroying the vacuum. The electron gun is fitted with a turret carrying four filaments and the change from one to another can be made in a few minutes.

The " Orthotron " is one of a number of similar equipments which are being provided by the National Health Service. Another is almost complete at the Western General Hospital, Edinburgh. A third is to be installed shortly at the Mount Vernon Hospital, Northwood, Middlesex. A fourth machine is destined for Australia and, like the Mount Vernon set, it is at present under construction in the manufacturer's research laboratories.

20MeV Betatron

The 20MeV betatron is an even more advanced equipment than the " Orthotron," and it is the only clinical application of the betatron in this country. Some information obtained from the use of betatrons is available in Europe and America and a little experience of very high-energy radiation has been obtained in this country, using a synchrotron at low output.

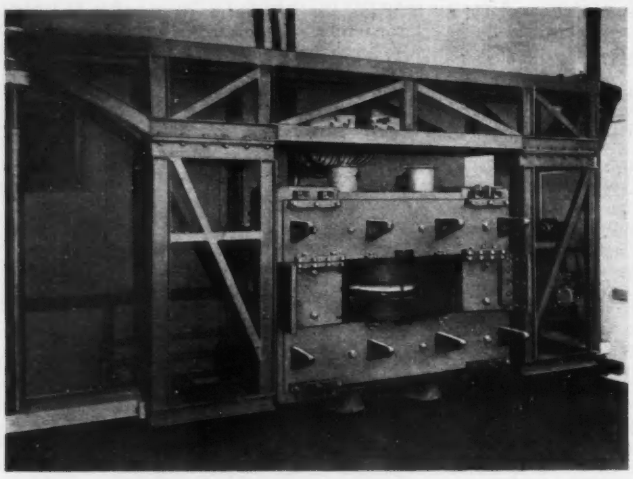


Fig. 5—20MeV betatron during installation at Christie Hospital, Manchester

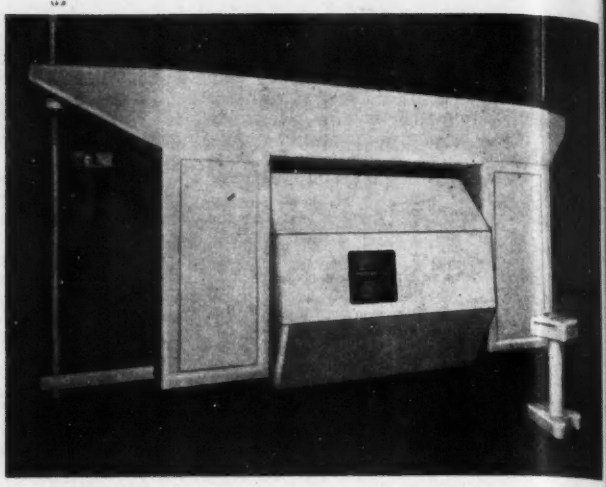


Fig. 6—20MeV betatron installed at the Christie Hospital. The inspection window and raising and lowering screws can be seen

Essentially, the betatron (Figs. 5 and 6) is a large alternating current magnet, with a central limb having specially shaped pole pieces between which is inserted a continuously evacuated glass toroid or "doughnut." The betatron magnet is excited from a 150 c/s tripling transformer fed from the three-phase mains supply. Electrons are injected at 60keV into the toroid by means of a small electron gun, which is pulsed to this voltage for 4 microseconds when the magnetic field between the poles is at an appropriate very small value and thus sends a stream of electrons circling round the doughnut. As the magnetic field increases sinusoidally the electrons circulate round the doughnut on an orbit of 19cm radius, and, for each revolution, gain 80 electron-volts of energy by magnetic induction. The electrons reach their maximum energy in 1/600th of a second, after which the orbit is expanded so that the electrons spiral outwards and hit a small platinum target attached to the end of the gun. The X-rays are produced in the forward direction in a relatively narrow cone, as a series of 2 microsecond pulses 150 times per second. The X-ray yield of the betatron before the insertion of compensating filters is 100 röntgens per minute at 1m from the target (as measured by a condenser thimble surrounded by 6cm of polystyrene).

To reduce the power consumption, a resonant circuit is employed, in which the magnet is paralleled with a 1600kVA condenser bank so that it is only necessary to supply the losses of the magnet, which amount to about 20kW. A smaller condenser is associated with the tripling transformer for power factor correction.

In Fig. 5 we show the betatron during its installation at the Christie Hospital The magnet, which weighs 7½ tons, can be rotated through 120 deg. so that the X-ray beam can be set at any direction from 15 deg. above the horizontal down to 15 deg. beyond the vertical. The framework in which the magnet is held can be raised or lowered through a distance of 7ft.

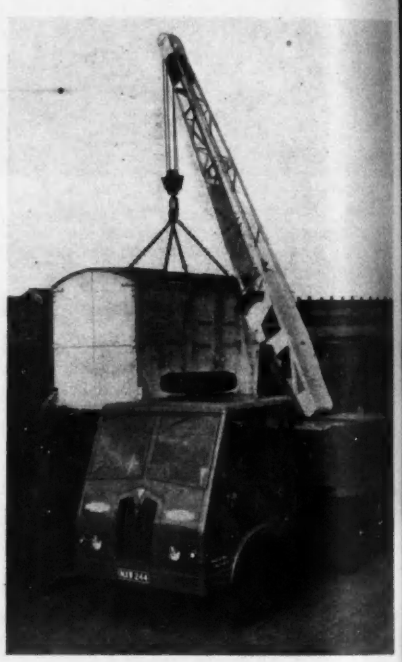
Radiation from the machine is applied to a patient through a beam-defining device or collimator, into which different treatment cones are fitted according to the field shape required. Each treatment cone contains a compensating filter to give uniform beam intensity across the treatment area. The maximum size of field that can be irradiated is 15cm diameter at 1m from the target. The control of the machine is relatively simple ; first, the magnet is energised, and then the X-ray beam is obtained by the adjustment of four simple controls, two of which are normally pre-set. The technical controls (Fig. 7) are grouped on the wall-mounted panels and the treatment controls are contained in the desk.

The betatron was presented to the Medical Research Council by Metropolitan-Vickers Electrical Company, Ltd.,

7-Ton Mobile Crane

A LORRY-MOUNTED mobile crane for service in railway yards and depots which is now being made by Steels Engineering Products, Ltd., Sunderland, has a lifting capacity of 7 tons at 10ft 6in radius, with a 20ft standard jib. This crane, known as the Coles "Leander," can be seen in operation in the accompanying illustration.

A diesel engine on the chassis drives a variable-voltage generator, which in turn supplies a separate traction motor for each of the four motions. Electric power is carried up through the hollow centre pillar of the crane and is transmitted via a rotary collector column to



Mobile crane with a capacity of 7 tons at 10ft 6in radius and designed for use in railway goods depots

the hoist, derrick and slew motors on the revolving superstructure. The jib is of cantilever lattice construction and optional lengths from 20ft up to 40ft in increments of 5ft can be supplied if required.

All the motions of hoist, derrick, slew and travel are controlled from the cab in which the operator is provided with a swivel seat so that facing forward he can drive his vehicle into position and then rotate his seat through 180 deg. to the crane operating position. Crane control is effected by one lever for each motion, which makes the electrical connections for both directions of motions. A duplicate travel controller is provided so that the travel motion can also be operated from this position.

The safety devices incorporated include a safe load indicator the self-resetting limit switches and electro-mechanical brakes which are applied to the hoist and derrick motions, on failure of the supply.

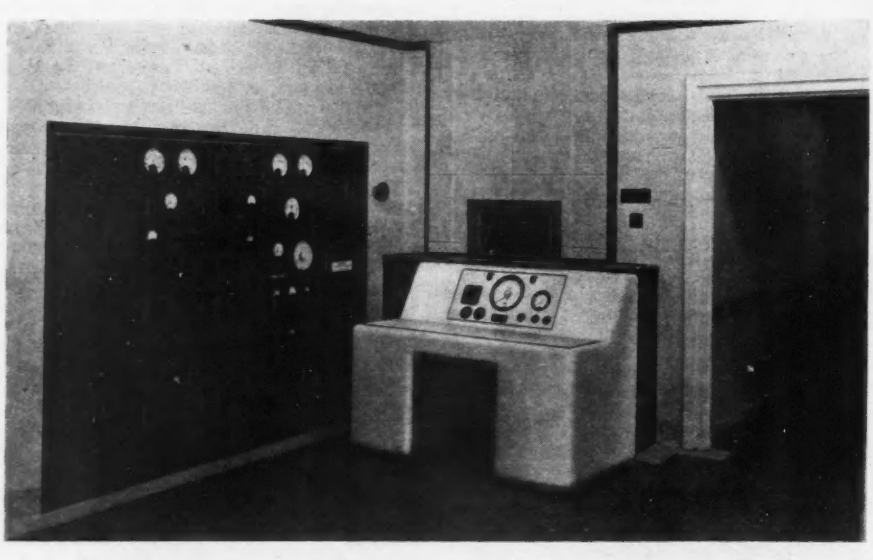
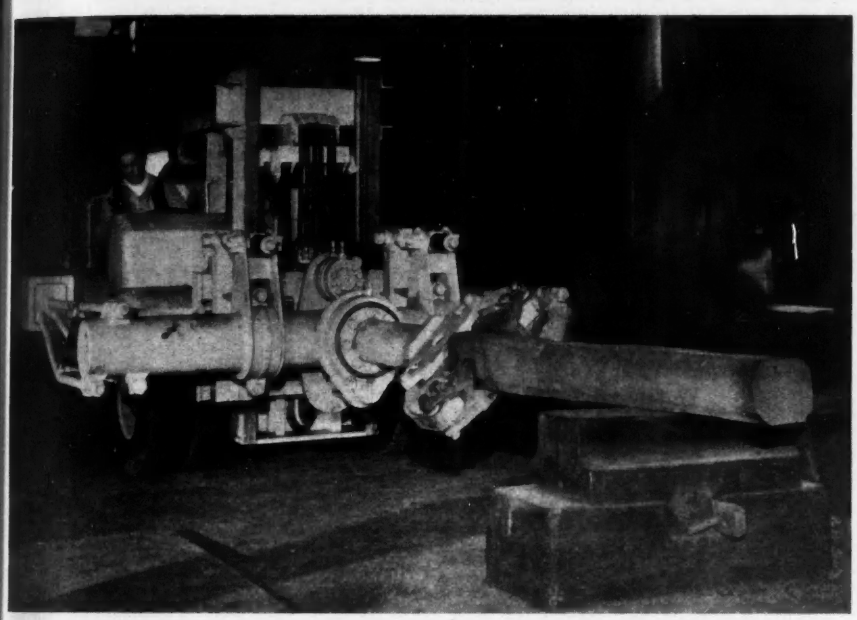


Fig. 7—Control facilities for the 20MeV betatron at the Christie Hospital, Manchester. The technical controls are on the left and the radiotherapy treatment controls are on the desk

Forging Manipulator

LAST week a series of demonstrations was held at the works of the English Steel Corporation, Ltd., of the first Salem-Brosius " Manipulet " to be made in this country under licence by the Head Wrightson Machine Company, Ltd., of Middlesbrough. This piece of equipment is designed as an attachment to a fork-lift truck and handles billets weighing up to 1500 lb and 6ft long. The equipment is used to take billets from the furnace to the forging hammer, where, without need for manual handling, the work can be rotated and moved vertically, laterally or longitudinally as required during the forging operation. With this equipment the arduous manual handling by tongsmen required in heavy and medium forging work is eliminated and less men are required in a forge team.

The " Manipulet " demonstrated can be seen in the photograph we reproduce on this page. It is fitted in place of the usual fork attachment on the mast of a Coventry Climax model " F.T.X." 10,000 lb capacity fork-lift truck. This truck is fitted with a 35 b.h.p. oil engine driving a four-speed forward and reverse gearbox through a fluid flywheel. The manipulator has a vertical adjustment on the mast of just under 4ft to give the tongs' arm a lowest horizontal position of 1ft 6in above ground level to 5ft 5in above. It has a hydraulically-operated lateral movement of 6in on the mast, which enables work held in the tongs to be moved across the hammer as in die forging. Longitudinal movement of the work is effected by driving the truck backwards and forwards as required in respect to the forging hammer itself. The tongs' arm is rotated by an Andrew Fraser hydraulic motor, driving through gearing to turn the work between forging operations.



" Manipulet " forging manipulator fitted to a fork-lift truck and designed to handle work weighing up to 1500 lb

The standard gripper jaws fitted on the tongs' arm are designed to hold billets from 4in to 14in square. If required, special jaws can be supplied to suit material of different shapes. Power for operating the jaws is obtained from the hydraulic system of the truck, which is set to 1250 lb per square inch. To ensure that the required pressure is maintained at the gripping jaws an accumulator precharged to 1000 lb per square inch is fitted in the hydraulic circuit.

The attachment is supported by a shock-absorbing system in the truck and this system is designed to counteract and counterbalance shocks transmitted to the machine from hammer blows on the billet. On the front of the machine stabilisers in the form of hard rubber rings are fitted round the main tubular members, and the amount by which the attachment can flex on these rubbers is restricted by heavy coil springs.

Counterweights mounted on arms on each side of the truck and carried on a fulcrum on the elevating portion of the truck assist the stabilisers to absorb the shock loads. These counterweights also move the centre of gravity of the loaded vehicle rearwards and help to increase its stability.

We are informed by Head Wrightson Machine Company, Ltd., that it is also building larger designs of the Salem-Brosius forging manipulators with capacities from 2000 lb to 20,000 lb.

Pneumatic Tools

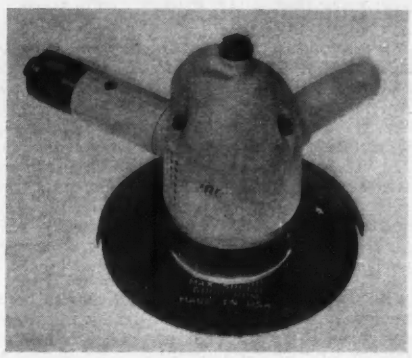
LAST week the Atlas Diesel Company, Ltd. arranged a demonstration at its Wembley works to show a number of new pneumatic tools which it is now making, together with some improved designs from its standard range of tools.

A high capacity pneumatic disc grinder, developed to take full advantage of reinforced, impregnated plastic grinding wheels, was shown in operation cutting off risers on castings, parting off tubing and for general finishing work. This machine, which weighs only 11 lb, is illustrated here. It has a multi-vane air motor developing 2½ h.p. at 8000 r.p.m., at which speed the air consumption is about 78 cubic feet per minute under full grinding load. It takes a 7in hub wheel and its well-finished cast housing has an integral silencer which reduces the exhaust noise.

The improved designs of air drills shown included two of $\frac{7}{16}$in and $\frac{3}{4}$in capacity, particularly intended for the aircraft industry where slower drilling speeds are required for alloy steels. These drills have a free running speed of 1700 and 1250 r.p.m., respectively, and their full load speeds are about 70 to 80 per cent of the free running speed.

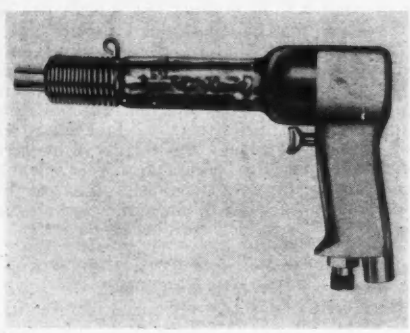
A new chipping hammer for light work, which weighs some 3 lb, is designed to impart up to 5300 blows a minute and has an air consumption of about 11 cubic feet per minute. In this tool the cap type chisel retainer has been replaced by a steel wedge retainer built into the head of the tool. This wedge fits into a groove on the chisel shank and it is held in position by a rubber block. A spring steel locking clip holding the wedge can be quickly and easily operated when it is required to change the chisel. The air exhausted from the tool is directed down on to the work to blow the chips clear of the working point.

A new range of long-stroke, slow hitting, high power riveting hammers has been introduced for use with high-tensile, light alloy rivets, now being used in the aircraft industry. These tools, one of which is illustrated herewith, are made in three sizes and in two forms with pistol-grip or open handles. The three models have strokes of 4in, 4½in and 6½in and blow frequencies of 1450, 1400 and 1100 strokes per minute, respectively. In each tool both the power and frequency of the blows can be adjusted to suit the conditions of working, by means of a knurled knob on the handle which controls the inlet valve stop. On its return stroke the piston of a tool works against an air cushion which serves to reduce the recoil.



Pneumatic disc grinder for use with plastic grinding wheels, which develops 2½ h.p. at 8000 r.p.m.

These riveters were demonstrated in use with the " High-Shear " rivets introduced into this country from the United States by Brown Brothers (Aircraft), Ltd. These rivets consist of an alloy steel or stainless steel pin which has a preformed head at one end and an annular groove machined near the end of the shank. In use a collar of aluminium alloy is placed over the top of the rivet shank after it has been inserted in the parts to be riveted. When this collar is then closed on the pin by use of a special tool in a riveter the metal flows into the annular groove to form a rigid locking head on the rivet. There is no upsetting of the pin as in normal riveting and the use of a high-tensile material gives a particularly high shear strength.



Long-stroke pneumatic riveter with controllable rate of hitting

An 8 cwt capacity air hoist now being made is driven by a vane air motor through gearing, and weighs some 56 lb. A positive spring-loaded brake in the hoist is automatically applied when the air supply is cut off, and released by air which is by-passed when a load is being raised or lowered. The air motor is driven in reverse during lowering of a load to give instantaneous and positive control at all times. The power of the motor is matched to the load rating of the hoist so that it will not operate to lift when overloaded.

COASTAL MINESWEEPER.—The coastal minesweeper H.M.S. " Letterston," was launched last month from the Belfast shipyard of Harland and Wolff, Ltd. The ship has a length of 152ft, a beam of 28ft 9in, and is of composite construction and is designed for operation in shallow coastal waters.

Utilisation of Sewage Sludge

We reproduce below abstracts from a paper entitled "The Utilisation and Disposal of Sewage Sludge," by C. B. Townend. presented on November 16th at the Public Works and Municipal Services Congress. The paper first outlines the properties of sludge and methods used to treat it. The choice between dumping or destruction, on the one hand, and utilisation on the other, the author points out, must always be made. The abstract herewith is concerned principally with the section of the paper on utilisation, as a manure, for land reclamation, or for by-products.*

A VERY great deal of information has been published over many years on the use of sewage sludge as a manure. In particular, a memorandum on "Sludge Utilisation in Agriculture" was issued by the Institute of Sewage Purification in 1943, while in 1946 the American Federation of Sewage Works Associations published a most comprehensive manual on the *Utilisation of Sewage Sludge as Fertiliser*. Both of these authorities stress the importance of the case for making the maximum use of sludge for growing food, but it is significant that both equally advise caution in assessing its value.

The British Institute says: "From past attempts to popularise the use of sludge, it is noted that many failures have been due more to the lack of knowledge on the part of producers and users alike, than to absence of intrinsic value in the sludge. Exaggerated claims as to its value in some areas have resulted in its complete condemnation, whilst attempts to market sludge through commercial channels have not always been wisely undertaken."

The American Federation states: "The sewage works operator should not be upset because the agriculturist approaches the use of the low-grade sludges with caution. On the contrary, he should welcome comment and suggest co-operative effort over a long period. Only by such procedure under accurate control by experienced workers can the confidence of the agriculturist be secured and a definite place for such material be assured."

Until the advent of artificial fertilisers within the past 100 years, animal manure was the main source of fertilising material, and still remains so in a great part of the world. Human wastes made their contribution to those manures and equally continue to do so in many large areas. But, as has been shown in a previous section, sewage sludge is a very different material from animal manure, mainly because of the admixture of so many of the other wastes of modern civilisation, and also because some of the valuable constituents of domestic wastes are lost by solution in the large volumes of water present in sewage. These facts must be accepted.

Fertilising Value of Sludge

Because of the great variation in conditions which exist from place to place, it is difficult to generalise on the fertilising value of sludge, but of the three principal requirements for plant growth, while sludge can supply useful amounts of nitrogen and phosphorus, it is always deficient in potash.

Normally, the potash content (K_2O) of any type of sludge does not exceed about 0·4 per cent of the dry solids, or perhaps only one-fifth of that present in farmyard manure. This is a deficiency which must be made good in other ways in most cases. On the other hand, the amounts both of nitrogen (N) and phosphorus (P_2O_5) contained in digested sludge may be about 1·5 to 3 per cent of the dry solids, being higher when secondary sludge is present in the mixture. These figures are not very different from those of farmyard manure.

Exceptionally, undigested activated sludge may contain 6 to 8 per cent nitrogen and 3 to 4 per cent of phosphorus, while humus sludge from percolating filters tends also to be as high as this in phosphorus.

It has been previously stressed that primary sludges should never be applied to the land without removal of harmful grease; in the great majority of cases, this will best be done by digestion. The effect of digestion is to lower the total nitrogen figure, but, on the other hand, the percentage of nitrogen to organic matter is higher for digested sludge than for raw sludge.

Secondary sludges do not require digestion for grease removal and their nitrogen content is much higher in the undigested state. Their direct application to the land in their original condition is therefore more beneficial, but to reduce their high water content and to avoid putrescibility and odours, they are often mixed with primary sludges and digested.

Prolonged exposure on drying beds will also lower the nitrogen content, particularly where the sludge is washed by heavy rain during drying. A further loss of nitrogen accompanied by a decrease in the volatile matter may be incurred by prolonged storage in dumps; these losses may amount to as much as 25 or 30 per cent in the course of a year or more, but, of course, they will depend to some extent on how far digestion was completed in the first place. On the other hand, air-dried sludge stored for a limited period for maturing in drying sheds, will improve so far as its availability of nitrogen is concerned.

Apart from primary constituents, the belief is widely held that sludge has considerable merit as a source of trace elements and of organic matter as humus. Since much of the substance of sludge had its origin in growing plants, this presumption would appear sound. Considerable work on the analysis of trace elements existing in sludge has been done at various places; in activated sludge at Milwaukee, for example, in addition to normal amounts of silicon, iron, aluminium, calcium, magnesium, potassium, sodium, sulphur and phosphorus, traceable amounts were found of titanium, manganese, copper, barium, zinc, lead, nickel, cobalt, chlorine, chromium, arsenic, boron and iodine.

Many of these have been established by agricultural research to have some role in natural processes, either as being indispensable to plant growth, or while not being indispensable may when present have some influence on plant growth, or when not being beneficial to plant growth are valuable as components of animal food. All such substances, of course, exist naturally in the soil and it is only where a deficiency occurs that additional amounts are required to be supplied in the form of fertilisers, or in other ways.

In addition to trace elements, much has been said in recent years about the ability of certain chemical substances, including such groups as hormones, to produce changes in growing plants such as root development, cell swelling, stem growth, ripening, and so on. Most of these substances are organic and occur as the result of the processes of natural decay of organic matter. Little has yet been established as to the possible value of sewage sludge in these respects, and, of course, they may already exist in the soil as the result of ordinary farming practice.

Most authorities accept the general desirability of a soil rich in decayed organic matter known by the general term of humus. Most sewage sludges do not have more than about one-half of their solids in the form of organic matter. Nevertheless, to this extent, they can provide a useful source of humus where this is required, and can benefit the soil in all of these ways.

Application

In actual application of sludge to land, much experimental work has been carried out on field tests, and the practical results of its use are well known.

As the result of the shortage of fertiliser during the second war, there developed a greatly increased demand for sewage sludge and many farmers experienced the use of the digested material for the first time. Because of this, much of the long-standing prejudice created by the use of the crude undigested sludges of earlier times was overcome, and a great part of the market expansion for sludge became permanent.

On the whole, this experience has shown that sludge is of distinct benefit as supplier of slow-acting nitrogen and phosphorus, and that the results of application last over a period of years rather than being confined to the short and more rapid period of concentration associated with artificial fertilisers. The general crop-producing power is somewhat less than with good farmyard manure and particularly so in the case of potatoes or other crops needing much potash. It has proved an excellent material for grass and, of course, its value for tomatoes is proverbial. Where sludge is applied in dry form, the best results have been obtained from the pulverised or powdered material. The physical improvement of the soil is valuable, but is rather different in nature from that obtained from farmyard manure, which contains more fibrous material.

While the bulk of sludge used for agriculture without doubt will continue to be applied to the land direct, there are certain advantages to be gained by its indirect use by means of composting with other waste organic materials, including house refuse and garden or farm wastes of many kinds. This has been referred to previously as a possible method of dehydration of liquid sludge. Its wider application, however, might be brought about by the use of dry pulverised sludge as an activator for the compost heap in place of animal manure which is becoming more scarce. This development was advocated by the late Sir Albert Howard, who stressed the economy of transporting the comparatively small weight of sludge required in the dry form to widely dispersed sites where the vegetable wastes were available for composting, rather than in attempting to bring the much larger weight of waste materials to the sludge disposal site and to transport the compost back again to the point where it was needed. For such a purpose, the contribution of the sewage disposal authority would be confined to the encouragement of the composter by making sludge available to him in a suitable form.

In some cases, discharges of certain chemical trade effluents render the resulting sludge quite unfit for agricultural purposes. This is particularly the case with metals and certain toxic constituents; some heavy metals, such as iron, form insoluble phosphates, not only in the sludge, but in the soil, which are not available for plants. Industrial sludges of this kind may be very harmful to plant life, but fortunately it is estimated that not more than 5 per cent of the total sludge produced in this country would be rendered useless in this way.

Land Reclamation

Almost in every part of the country there are areas of land which could be reclaimed for grass growing or for agricultural use. These consist of inferior soils of sand, chalk, and so on, or of refuse dumps, ash tips and spoil disposal sites of various kinds. Marginal lands can be considerably improved by ploughing in several inches of sewage sludge, while in the case of dumps it would be necessary to spread sludge over the entire area to a depth of 12in or so, instead of using top soil, which is very often unobtainable. Grass will grow on most sludges and in the course of time other crops could be grown, if necessary. In many cases it would be possible to pump the sludge to the chosen site and dry it *in situ* at comparatively little cost.

As an indication of what can be achieved in this way, two cases in recent years have been outstanding, one in this country at Birmingham, and the other at Los Angeles in America. In the former case, an ash dump adjoining a power station has been most successfully reclaimed in this way, while in the latter case, the Hyperion sewage plant, which was constructed by excavating sand dunes on the sea front, has been most beautifully landscaped with grass, shrubs and flowers, with the aid of a few inches of sludge on virgin sea sand. The possibilities of such a valuable use for sludge appear to be worth further exploration.

By-Products

The most valuable and easily used by-product to be obtained from the disposal of a normal sewage is that of methane gas generated from the digestion of sludge. The yield of sludge gas may vary considerably, but from the mixed sludges of a complete treatment plant, rather more than 1·0 cubic feet per day can be expected per head of population. From primary sludge alone this figure may not reach more than 0·8 cubic feet per day. Sludge gas usually has a methane content of about 65 to 70 per cent and a calorific value of 650 to 700 B.Th.U.s per cubic foot.

From the national point of view, therefore,

[* Chief Engineer, Main Drainage Department, Middlesex C.C.

the possibilities of its utilisation are considerable. Assuming the sludge digestion process were ultimately adopted for only 30,000,000 people in this country, a total daily output of something like 25,000,000 cubic feet of gas could be expected. In thermal value this would be equivalent to some 270,000 tons of coal, or about 36,000,000 gallons of fuel oil per annum.

At many sewage works, a large proportion or even the whole of this energy would be needed to meet the requirements of the plant itself, so that none would be available for external uses, but, even so, the saving of national resources would be just as real.

If the gas is used by direct means for heating the digestion plant, then up to 40 per cent of the total gas production may be needed in cold weather for this purpose. A more profitable method of using it from the thermal point of view is for the generation of power in which case the whole of the gas can be used as fuel in the engines, and the digestion plant can be adequately heated by waste heat from cooling water and exhaust gases.

With modern dual-fuel engines, even a small town of 20,000 population could expect to produce 1200 b.h.p.-hours per day which would cover 120 h.p. for ten hours, or 50 h.p. continuously. A small plant of this kind, however, would not usually be economic unless it could be operated in conjunction with other necessary plant without engaging special staff.

Each case would have to be judged on its merits ; if the total additional costs, including loan charges, maintenance, &c., were less than the cost of purchasing electricity, then power production becomes economic. Where a diesel oil engine is fully competitive with purchased current, then the value of the gas would be that of the oil displaced, equivalent to 4s. per 1000 cubic feet, or about 7½d. per therm.

If any heating load exists within easy reach, such as for buildings, or boilers, then the value of the gas may obviously be greater. In exceptional cases it may be used by compressing into storage cylinders at 3000 lb per square inch as a fuel for motor vehicles, for which purpose the equivalent of 1 gallon of petrol is obtained daily from each 250 of the contributing population. Such an installation, however, would not be worth while under peacetime conditions, except in special cases.

Methane can also be used as a fuel for sludge drying. With the development of the gas turbine the large volumes of high-temperature exhaust gases might be used indirectly for this purpose with advantage. Other uses for methane include its possible sale for blending into the public supply, as a raw material for chemical manufacture, and so on. In South Africa sufficient cyanide is produced by the synthesis of methane and ammonia to supply the whole of the requirements of the gold mining industry.

While every sewage contains considerable amounts of grease, these are usually not worth recovering separately, particularly as they make a valuable contribution to the production of methane gas where sludge digestion is operated. In certain special cases, however, where large amounts of grease are received from trade effluents, such as those of the woollen industry in Yorkshire, it becomes essential to remove them in the course of sewage purification, a procedure which is simultaneously profitable.

The special processes adopted are preliminary treatment by acid cracking in one or two stages, followed by hot pressing or solvent extraction. The recovered grease is then refined and clarified. In the classic case of Bradford, a large number of by-products have been developed from the crude grease so profitably that in many years the sewage works undertaking has been operated at a profit. The case of Bradford, however, must be considered as quite exceptional.

In recent years, activated sludge has been confirmed as a source of vitamin B.12. Considerable work has been done on this subject, particularly in America, and while there may be some possibilities in this direction, development is still in its early stages. The case is interesting, nevertheless, as an example of the trend of thought in regarding sludge as a potential source of new end-products.

Distribution in Liquid Form

Where it can be carried out the cheapest way of applying sludge to the land is by pumping and distributing in liquid form. This has been practised very successfully at Wolverhampton for at least twenty-five years, both on arable and grass land. The sludge is pumped up to a distance of 3 miles through permanent mains to high points in each area, and thence to individual fields by portable pipes.

Liquid application has the advantage of cutting out special drying, double handling and mechanical transport ; it is low in capital cost and labour ; it makes full use of the manurial constituents of the sludge, including those contained in the liquid, such as ammonia and potassium compounds otherwise lost.

The method represents a return to the sewage farming of eighty years ago with two important differences—(1) the water is now only about 1 per cent of its former volume, and (2) of the solids, grease has been removed, and offensive organic matter stabilised by digestion. In the interim, the pumping of materials like sludge has become one of the simplest of operations and the cheapest way of transporting solid matter. These advantages are sufficiently attractive to make the method worthy of the first consideration.

The dressings are applied at the rate of 10 tons of dry solids per acre once in three years for arable land, and at one-third of this rate every year for grass land. Even at the former dosage the liquid depth is only 2½in, so that no problem is caused by interrupting farm operations to any serious extent.

At these rates of application a population of about 1500 to 2000 would be served by 1 acre. For small towns, sufficient area of farm land should be found within easy range, but larger communities should not find it difficult to pump many miles if necessary. Obviously, a large effort would be required over a long period to gain the co-operation of farmers in such a scheme, but this might be achieved by a gradual change over from distribution of the dried material.

In this connection, it should be noted that if the dressing of 10 tons of dry solids per acre is suitable for any particular sludge, then the same total area of land would be needed within easy reach of any town to take sludge in the dry form as in the liquid state. The advantage of dry sludge then would only arise from the possibility of its distribution by vehicle to more remote or distant areas, and from the greater flexibility in meeting maximum demands during the best weather periods.

Distribution in Dry Form

The total costs of applying sludge in the dry form must eventually cover drying, transport and spreading. The costs of drying will rise rapidly with the amount of water removed ; on the other hand, the cost of transport is increased by the weight of water carried, as well as by the length of haul. The cost of spreading will be affected again by the weight of unnecessary water and by the ease of handling or otherwise ; this cost will be paid by the farmer, but will influence the price he is prepared to pay for the sludge.

Thus, it is not to be expected that a 70 per cent water sludge (containing 2·3 tons of water to every ton of solids) can be used at any great distance from the point of production ; this applies to all partially dewatered sludges, whether air dried or filter cake. Air dried sludge at 50 per cent moisture (with only 1 ton of surplus water) can be hauled much farther, but will still have a limit of perhaps 25 miles or so. For a longer range, it is essential to dry sludge by heat down to 10 per cent moisture, but the cost of doing this will probably put the material beyond the reach of the buyer, even in the case of the higher nitrogen qualities of activated sludge. The combination of air drying to 50 per cent moisture followed by heat drying to 10 per cent is cheaper, but can only be applied to digested mixed sludges which are not so high in nitrogen. In all these matters, local conditions will vary enormously and the methods to be used must be chosen accordingly.

Transport

In the disposal of sludge it is often overlooked that the movement of solids in the liquid form by pumping is usually by far the cheapest and most reliable form of transport which can be arranged.

Because of this fact the location of sewage works to-day can be decided independently of the arrangements for sludge disposal. After separation and preferably digestion at the sewage works site, the sludge can be pumped away for treatment, drying, or disposal by any chosen method to a convenient site selected on its own merits. The methods employed do not need to be determined by restrictions of area or other causes at the sewage works, and can be more readily adapted to the requirements of disposal facilities available.

In this country, sludge mains up to 7 miles in length have been operated for many years, while in America the distance has reached 13 miles. There is no reason why sludge should not be pumped 20 or 30 miles if necessary, and this would considerably enlarge the possibilities for its return to the land, particularly in the case of large towns or conurbations where agricultural areas are not easily accessible.

The possibilities of liquid application to the land have already been discussed. For the facilitating of such methods, some limited form of sludge "grid" might not be out of the question. Where conditions are suitable, economy is to be expected wherever transportation by vehicle can be reduced or eliminated.

Compost

The value of the composting of sewage sludge with waste organic materials has already been referred to, but if this is to be carried out at reasonably low cost, the scale of operation must always be limited.

The great economy of water carriage favours the large-scale operation of drainage undertakings and therefore the concentration of sludge from large areas to one point. The relatively high cost of transporting dry refuse or other organic wastes, on the other hand, will severely limit the size of area from which such materials can be centralised without undue expense ; the same consideration applies to the delivery of composted materials from the central point back to the users.

Thus, only in the case of the small town will it be economic for composting to be carried out by the local authority itself. In the larger district, sludge must be dispersed after suitable treatment to the points where composting can most economically be carried out. This might be done by pumping liquid sludge to rural areas, or by the distribution of dry powder as advocated by the late Sir Albert Howard.

Conservation

While every effort should be directed to returning sludge to the land by direct or indirect methods, its importance from the national point of view should not be exaggerated. It has been estimated that the total dry solids in the sewage draining to outfall works in England and Wales is about 800,000 tons per annum, including that at present boated to sea. Of this amount, 350,000 tons is already being used on the land and 50,000 tons of industrial sludge is unsuitable. These figures would be considerably reduced by digestion treatment which is essential in most cases. At the rate of dressing to land of 10 tons per acre once in every three years, it is obvious that if the whole of the national production of sludge were directed to agricultural use, it could not serve more than perhaps 200,000 acres, which is an extremely small proportion of the 24,000,000 acres of farming land in this country. Nevertheless, waste even on this scale should be avoided.

The methods for the treatment and processing of sludge have been revolutionised during the past fifty years, and there are now many tools for carrying out the job. Nevertheless, very much more remains yet to be done in this field.

Weaste Refinery.—We are informed that Head Wrightson Processes, Ltd., has completed an extension to the Weaste refinery of Berry Wiggins and Co., Ltd., which raises the output by 500 barrels per day. The original installation, which was built in 1930, has been rearranged to accommodate the new units and several old units have been redesigned in order to increase overall efficiency.

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AN "INTERIM REPORT"

When reviewing some fuel and power projects initiated by the Ministry of Fuel and Power, Sir Harold Roxbee Cox once remarked upon the dissatisfaction afforded the writer of an "interim report," such as was then his task, as compared with the pleasure which came from the contemplation of a projected work or the relief afforded by bringing a work to a satisfying conclusion. Since that Thomas Hawksley Lecture was presented three years ago the gas turbine has in some fields prospered; in others its progress has been laboured; and in still others seemingly hopeful projects have already fallen by the wayside. So much can be gathered from what has already been published about gas turbine researches. The absence of reports about other research projects can, perhaps, be regarded as a consequence of that distaste for, and even fear of, the "interim report" which Sir Harold expressed. It was therefore all the more interesting to listen to the frank and courageous account Professor Mordell presented on Friday, November 5th, to the Institution of Mechanical Engineers about his hopes, his fears and his mistakes in developing a coal-fired exhaust-heated locomotive gas turbine at McGill University, Montreal, a site which denied him that intimate contact with contemporary workers in his field which others enjoy and placed severe limitations on his resources.

In this country the promise of utilising pulverised coal in a gas turbine has received much attention. The corrosive and erosive effects of the ash on the turbine are the major difficulties it presents if a simple open cycle is retained, and combustion chambers of the "straight-through" vortex and slagging principle have been extensively rig tested. With the two former designs the particles are burnt in suspension at the maximum cycle pressure and the whole mass flow has to be cleaned. An experimental 500 h.p. gas turbine using this system was first run in this country early in 1951. With the slagging combustion chamber, combustion is arranged to take place on the walls, from which most of the ash can be collected in a molten state; only the combustion gases need be cleaned, the remaining 60 per cent of the total mass flow being introduced after the cleaners. Such a system is being tried out on a 2000kW set. But about neither of these researches is much technical data yet available. In yet another open-cycle system, which retains internal combustion, the coal is first gasified in a pressurised gas producer working at 6 atm. Here only the air bled from the compressor to the gas producer and the combustion gases produced—about 10 per cent of the mass flow—need be cleaned. A pilot scale gas producer was running in 1951. But full technical details are still awaited. Still employing the simple open cycle, there remains the exhaust heated arrangement employing external combustion. With such a cycle none of the combustion gases pass through the turbine, the cycle air being heated in an air heater. This cycle has been adopted for a locomotive gas turbine project in this country. The total throughput after exhaust from the turbine passes to a "dry" form of combustion chamber working at atmospheric pressure and passes thence to the air heater from which it exhausts to atmosphere. Work has been proceeding on this cycle for three years, but the running of a set is not apparently expected for another year. It appears to be the simplest of all coal-burning cycles, but because of the need to use special materials in the heat exchanger or air heater it is also costly. Moreover, though it relieves the turbine of corrosive and erosive damage, it nevertheless aggravates heat transfer and constructional problems in the air heater itself. The McGill set departs from this simple arrangement in the design of the heat exchanger and in the combustion chamber used. A slagging chamber is employed. Part of the mass flow and 30 per cent of the ash pass through it to the annular tube stack of a primary air heater. The larger portion of the turbine exhaust, however, by-passes the combustion chamber. The two flows then converge on a secondary heat exchanger of more conventional design before exhausting to atmosphere. As a consequence of this arrangement Professor Mordell faced new problems associated both with the slagging form of chamber and the construction of a heat exchanger exposed to a gas inlet temperature of 1000 deg. Cent. For locomotive work the relatively high heat release of a slagging chamber (1,000,000 British thermal units per cubic foot per hour was obtained) and the collection of the ash as slag are very real advantages. But the problem of cooling the walls and baffles is no less real and the finding of a suitable lining to give reasonable life has proved equally difficult. The method of water cooling adopted absorbed 14 per cent of the heat developed. Fortunately, however, this heat can be used very profitably in heating the train. In designing the heat exchanger it was necessary to legislate for the consequences of overheating and the passing of 30 per cent of the ash content. If this ash were not completely in a "dry" state and able to pass without sticking to the tubes the efficiency and life of the unit would be gravely jeopardised. This ash condition has been found to depend critically on temperature, time and dimensional factors, not clearly understood even now.

Professor Mordell nevertheless accepted without dismay the hazards associated with this task when he began, nor was he discouraged by whatever information he could glean from his few visits to this country as his work progressed. He consequently proved well able to defend himself in the very instructive debate which followed his address. He was able to point out that his turbine was running very successfully and that he believed it to be the first of its kind to run. It was true that different equipment might have been chosen had wider selection been possible. But he had had to make do with what he was able to beg or was offered. Indeed, it was this latter circumstance which dictated his use of an American slagging chamber in the first case. He and his staff had had to overcome unusual expansion troubles in order to adapt the whole installation to a good, but old, aeronautical gas turbine. For much of the engineering work involved he acknowledged the skilled outside assistance he received, but much of the fundamental research he had had to undertake was done by his own staff and submitted in some cases as thesis material. It is always instructive to hear about mistakes. There, Professor Mordell was very frank. An over-elaborate heat exchanger had been built. In action it proved to be very poor aerodynamically; and its complications did not justify themselves thermally anyway. A much simpler and cheaper contraflow unit is being made which, he claimed, would give the required performance with equal safety. It had been found that slag notches in small furnaces either burn away or coke up, but already that problem, he thought, was more than halfway towards a cure. Enough was now known

about this set to keep the ash "dry," a condition which rendered tube fouling problems minor ones. On the rail the worst troubles now likely would do no more than slow up the train. Another principal trouble, which had been foreseen, lay in the maintenance of furnace walls. But he asserted that the cost of maintenance of one rail diesel engine for a year was equivalent to the cost of twenty-five furnace linings. He estimated that the extra capital cost of the gas turbine over and above that of the diesel engine could be recovered within four years. He stressed the need for a coal-burning gas-turbo locomotive in Canada, and he was confident that his arrangement of the exhaust heat cycle was a good one. It permitted a rugged construction. There was no risk of thermal shock with it, nor the consequent shedding of turbine blades when things went wrong. Practical railwaymen, of course, will feel far less confidence in the merits of the device. But optimism amongst research workers is a virtue not a defect, and the Professor showed himself well aware that much more running will be needed before his claims can be substantiated. In truth, Professor Mordell was presenting an "interim report," from which no final conclusions can be drawn. We applaud his courage; and we believe that if others were equally bold technical advance might well be hastened. After all, there is nothing shameful about making mistakes so long as they are recognised for what they are; nor is there anything shameful in confessing that solutions to difficult problems have not been found so long as it can be shown that they are being vigorously attacked. No doubt it is psychologically dissatisfying for a research worker to present an interim report full of loose ends and "ifs" and "buts." But it is certainly valuable to others working in the same field; and not without value, we believe, to those whose report is thus presented.

CHEAPER OR FASTER FLYING?

The gas turbine offered to aircraft designers a prime mover capable of developing very high thrusts and having a very high thrust-to-weight ratio and a small frontal area. Its application to aircraft has resulted in a great evolutionary leap in aeronautical development. It has made possible the construction of larger aircraft flying at greater speeds and higher altitudes than were attainable before, with future limits seemingly set only by metallurgical inadequacies. But Dr. Lachmann indicates in the paper which we have abstracted on page 711 that this same prime mover has stimulated yet another evolution in design philosophy which, in the field of civil aviation, may affect the flying machine just as significantly, but in an almost opposite direction. He reviews the development of boundary layer control and circulation control, which has been proceeding apace and in great secrecy in many parts of the world since the beginning of the last war. He describes how by infusing kinetic energy into the boundary layer of an aerofoil, either by sucking or blowing through perforations in the aerofoil skin, separation of the flow can be prevented and very great reductions in drag can be achieved. The achievement in an ideal case of complete laminar flow by this means on the wetted surface of an aircraft reduces its thrust requirement for a given performance by as much as 75 per cent; the range of the aircraft could be increased by one-half and the cruising altitude be reduced by 20 per cent. He maintains that the practicability of the process has already been handsomely demonstrated, but suggests that, in comparison with America, this country has much leeway to make up in solving the engineering problems presented. He also warns that suitable gas turbines small enough for the reduced order of thrust required will need to be developed, as those at present existing are far too big.

It could be gathered from the debate that the wisdom of exploiting this revolutionary development is viewed with some misgiving in this country at the present time. It is true that such an aircraft, should its pneumatic machinery fail or were its effectiveness overall reduced by external factors such as ice or rain, would appear to be in dire distress with so little basic thrust with which to meet the increased drag. On the other hand, aircraft incorporating this principle in conjunction with suitable flaps are, it seems, endowed with particularly safe handling and stalling characteristics. Indeed, it has been demonstrated that desirable slow-speed characteristics, of which the last fifteen years' development has tended to deprive aircraft, can be restored to them. Very seldom, of course, are projects of so advanced a character propounded without objections being stressed. For practically minded designers and operators see the hazards involved as clearly as the research worker sees the opportunities displayed. But to hasten the building of an experimental "laminar" aircraft in this country might well prove a project worthy of the effort and expenditure involved. It is, indeed, a possibility that such an aircraft could be built within the bounds of present knowledge. For neither great size nor great speed at extreme altidudes would be necessary to demonstrate the economy, the practicability and perhaps the defects of the craft. The prime advantage to accrue can be clearly seen, that of reducing drag and thereby greatly improving economy in operation. It is no mean one. Practicability and safety would need to be demonstrated also. It is, of course, true that the successful outcome of that kind of project can never be guaranteed. But successful or unsuccessful, much is always learnt; and in this instance some of what was learnt might well find application in other fields besides that of aircraft design.

Literature

The Dynamics and Thermodynamics of Compressible Fluid Flow. Vol. II. By A. H. SHAPIRO. New York: Ronald Press Company, 15, East 26th Street, New York, 10, N.Y. Price 16 dollars.

THIS second volume completes Professor Shapiro's comprehensive treatise on compressible flow. It is divided into four parts, beginning with Part V of the book as a whole, which deals with pure supersonic flow. Part V was started at the end of Volume I and is continued in the second volume with chapters on axially symmetric flow, on flow past wings of finite span, and on flow with very large Mach numbers which exhibits special features and has been distinguished by the name hypersonic flow. Part VI deals with the difficult field of mixed flow and contains chapters on mixed subsonic-supersonic flow treated by the hodograph method, on various analytic methods of dealing with transonic flow, and on drag and lift at transonic speeds. Unsteady motion in one dimension, including the cases of continuous flow and shock waves, is dealt with in Part VII. In the final part the influence of viscosity and heat conductivity, two properties of real gases which have been largely ignored in the earlier sections, is considered. There are chapters on laminar and turbulent boundary layers and on flow in tubes. Shock wave patterns arising from boundary layer-shock wave interactions are considered in the earlier sections of the book and the discussion of these phenomena is completed in the final chapter.

According to the introduction, these volumes are intended "as an introductory text in the subject as well as a reference work for some of its more advanced phases" and "the basic objective has been to make the book of practical value for engineering purposes." These intentions provide the framework for a very valuable book, and it may be more useful to indicate here how far the author has achieved his objectives than to attempt a detailed criticism of the contents. In the reviewer's opinion Professor Shapiro has undoubtedly succeeded. He has provided a thorough account of the extent of fundamental knowledge for each branch of the subject and there is a happy balance between theoretical methods and experimental results. The practical illustrations are drawn from many fields of application, including ballistics and explosions, the flight of high-speed aircraft and rockets, jet engines and rocket motors, turbines, compressors, wind tunnels, and nuclear reactor coolant circuits.

The author has the ability to write simply and lucidly and maintains a high standard throughout. There is a unity about these volumes which is no doubt an advantage which is gained when there is a single author as against a number of specialists, each responsible for a section. The books are a pleasure to use, the printing, photographs, and diagrams are excellent, there are many references and a detailed index. As in the first volume, so most chapters in this second one are provided with a number of problems by means of which the reader can test his grasp of the subject; unfortunately the answers are not provided.

Altogether these are two admirable volumes and constitute an impressive achievement on the part of their author. Anyone who acquires them will return to them again and again, but it is unfortunate that the high cost, 16 dollars for each volume, may greatly restrict their use.

Obituary

LIEUT.-COLONEL P. J. COWAN, M.B.E.

WE have learned with regret of the death of Lieut.-Colonel Percy John Cowan, M.I.C.E., M.I.Mech.E., which occurred on Monday last, November 15th, at his home at Surbiton, Surrey. Lieut.-Colonel Cowan was joint editor of our contemporary, *Engineering*, from 1924 until his retirement in 1938. He joined the editorial staff of that journal in 1906.

Books Received

B.B.C. Handbook, 1955. London: British Broadcasting Corporation, Broadcasting House, W.1. Price 5s.

Dust is Dangerous. By C. N. Davies. London: Faber and Faber, Ltd., 24, Russell Square, W.C.1. Price 21s.

Letter to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

BROAD FLANGED BEAMS

SIR,—I have read with great interest the article appearing on page 611 of THE ENGINEER of October 29, 1954, under the heading "Wide Flange Beam Rolling Mill." It may interest both your readers and your American Editor to know that another Grey Mill, that of Differdange in Luxembourg, was in existence some years before that of Bethlehem: my firm has in fact been marketing as distributors these Differdange grey beams—which we call broad flange beams, grey process—continuously since 1902.

These broad, or wide, flange beams are in fact a natural requirement of the steelwork designer to reduce or eliminate the frequent recourse to costly plated joists and built-up sections for columns and girders. The problem, overcome by Henry Grey, was how to roll such a section and yet ensure that the whole section would be homogeneous and properly rolled, particularly on the flange extremities—limited to a maximum of 7½in to 8in on the closed pass type of mill used for ordinary R.S. joists. The grey mill overcomes the difficulty by employing large horizontal rolls for rolling the webs, and independent vertical rolls for the flanges. The product resulting is more akin in quality and finish to a universal plate. In addition to the higher load-carrying capacity for weight when used as a stanchion and the great economies in depth and fabrication when used as a beam or horizontal girder, these B.F. beams are rolled with parallel flanges without taper, thus dispensing with levelling taper washers and the shaping of trimmer joists.

The snag for the manufacturer was and is the very high capital cost of the plant required—from the range of ingots required, and gigantic blooming, roughing and finishing mills, and the general massiveness of the plant required in all aspects. But the very small increase in price per ton of finished beams occasioned by the cost of the plant is usually recovered many times over by the savings resulting from their use, as proved by the tremendous consumption of these beams in the U.S.A. and Europe: the demand in England has been restrained by the absence of a grey mill in any British works and the artificial barrier, at consumers' expense, as usual, of penal import duties and other devices. Another advantage of the grey mill is that it permits the production of a large range of sizes—currently 4in by 4in nominal by 11 lb/ft up to nearly 40in by 12in by 234 lb/ft with a nearly infinite range of sizes and weights in between these extremes.

The Differdange Mill call their wide flange sections Poutrelles Grey (grey girders), the Americans usually employ the descriptive term "H" beams and also wide flange beams. This firm coined the description broad flange beams, grey process.

J. C. SKELTON
Director of R. A. Skelton and Co.,
Steel and Engineering, Ltd.
London, E.C.2.
November 8th.

STRENGTHENING THE OUSEBURN VIADUCT.—We have received from the Quasi-Arc Company, Ltd., the following note on a recent repair at the Ouseburn Viaduct, Newcastle upon Tyne. This viaduct carries the main line North to Scotland and was built in 1870, the construction being riveted wrought iron arch ribs, spandrils, stringers, cross beams and decking with longitudinal timber waybeams. Due to general spandril weakness and lateral instability under modern traffic it was necessary to carry out extensive repairs to the decking and strengthen the spandrils. The strengthening was carried out by welding braced columns from channel sections between the arches, and the main deck girders. Mild steel plates were first welded to the webs of the arches and linked together with two channel sections providing a cradle for supporting the main columns. A similar cradle links the main deck girders.

Jubilee of the Thermionic Valve

FIFTY years have elapsed since John Ambrose (later Sir Ambrose) Fleming lodged his application on November 16, 1904, for a patent to cover a piece of apparatus which he called an "oscillation valve." To mark the jubilee of this event a special meeting of the Institution of Electrical Engineers was held in London on Tuesday, November 16th last. At the same time, an exhibition of some of the apparatus used by Fleming in his early experiments was arranged in the electrical engineering laboratories at University College, London, where, it will be recalled, Sir Ambrose Fleming was professor of electrical engineering from 1885 to 1926.

Although some of the subsequent history of the thermionic valve is clouded by controversy, the events that led up to Fleming's original invention are clear enough. In the early years of the century, Fleming, as technical consultant to Marconi's Wireless Telegraph Company, was collaborating with Marconi in the now historic experiments to establish communication across the Atlantic by wireless telegraphy, between Poldu and Newfoundland. One of their problems was to devise a better means of detecting the weak signals, than by the existing instruments—the coherer and the magnetic detector. Fleming's first attempt to find an alternative detector led him to investigate chemical rectifiers, but without success. Then in October, 1904, he recalled his earlier interest in what came to be known as the "Edison Effect." Edison had been studying the possibilities of prolonging the life of carbon filament lamps and he had discovered that if a piece of tinfoil was introduced in the bulb and connected to the positive side of the filament, a small direct current could be detected between the filament and the tinfoil: if, however, the foil was connected to the negative side of the filament no current was passed. This effect had been investigated, inconclusively, by Preece and by Fleming and then, in 1899, it had been explained, by J. J. Thomson, as a flow of electrons from the filament to the foil. But it remained no more than a scientific curiosity until, in 1904, Fleming conceived the notion of adapting the device as a valve, making use of its ability to pass a current in one direction only.

He first demonstrated in his laboratory that one of the filament lamps used in his earlier experiments on the "Edison Effect" would, in fact, serve as a detector of signals from a spark transmitter. He then improved the design of the original apparatus by replacing the metal foil by a cylinder completely surrounding the filament, and it was in this form that the device was described as an "oscillation valve" in Patent Specification No. 24,850 of 1904.

This, briefly, was the invention that was celebrated at the commemorative meeting of the Institution of Electrical Engineers on November 16th. The proceedings were opened at 2.30 p.m. by the Marquess of Salisbury, Lord President of the Council, who spoke of the revolutionary changes, both social and industrial, that sprang from the invention of the thermionic valve, which formed the basis of wireless communication, broadcasting and television, and of numerous industrial applications, such as measuring, sorting, counting and controlling. Lord Salisbury said that he felt it would be a pity if Great Britain allowed other countries to establish and maintain a lead in some of these applications, although he admitted that in America, for example, the high cost of labour was one factor that stimulated the rapidly growing uses of electronic equipment as an aid to production.

The proceedings at the I.E.E. meeting continued with a series of three lectures, each dealing with a separate stage in the development of the thermionic valve during the past fifty years. In the first lecture, Professor G. W. O. Howe gave a stimulating account of the genesis of the thermionic valve, based on the early life and work of Sir Ambrose Fleming. He related how Fleming, while still an undergraduate, had to work in an accountant's office to earn enough to pay his fees; how Fleming went to St. John's College, Cambridge, to study under Clerk Maxwell; how, at some of Maxwell's lectures, Fleming was the only student present. He described Fleming's work as electrician to the Edison Electric Light Company—work which drew his attention to the "Edison Effect" and was the inspiration of the invention of the thermionic valve. Professor Howe referred to the bitterness that arose between Fleming and Lee De Forest, the inventor of the triode valve, and to the prolonged litigation that ensued.

In the second lecture, Sir Edward Appleton discussed the evolution of thermionic devices from the development of the triode up to 1939. He paid a tribute to the invention of the grid by De Forest, describing it as a great invention, the full potentialities of which could not be assessed for a number of years, during which the characteristics of the triode valve were thoroughly investigated. Sir Edward went on to trace the evolution of various descendants of the triode.

In the third lecture Dr. J. Thompson brought the story up to date by describing developments in thermionic devices since 1939.

To provide a physical illustration for the lectures, an exhibition of valves was staged in the Institution building. This representative selection of exhibits, arranged and displayed specially for the occasion, to show the evolution of the thermionic valve from Fleming's day to the present time, had all the attributes that one might have expected of a permanent historical exhibition. There were separate displays dealing with Fleming lamps and valves; progress in the diode and triode valves up to 1918 and thereafter; developments in emission; transmitting valves and valves for special purposes; tetrodes and pentodes; multi-electrode valves; developments in "miniaturisation," and transit-time devices, such as klystrons, magnetrons, transmit-receive switches and travelling-wave tubes.

The exhibition held in the electrical engineering laboratories of University College was arranged to show something of Fleming's experimental work on valves and other aspects of electrical engineering, to emphasise the limitations under which his work was carried out, and to indicate some of the developments that originated in the thermionic valve.

The evolution of the thermionic valve was illustrated by a series of exhibits, including a collection of Edison lamps which were brought back by Fleming from Edison's laboratory. There was also a group of Edison Swan lamps which formed the experimental basis for the original thermionic valves. A number of early Fleming valves were also exhibited. Among the interesting documents associated with this early phase of Fleming's work was a signed copy of the original Patent Specification and of a later Specification taken out in 1908 for a diode valve. Here, it is, perhaps, appropriate to mention another document which is typical of Sir Ambrose Fleming—a letter written by him in 1944, at the age of ninety-five, expressing his dislike of the word "diode." In this letter he complained: "Others have, I regret to say, employed the word 'diode' in place of the simpler word 'valve.' There seems to be no advantage in making use of scientific gibberish of this kind when simple English dictionary words are available which are intelligible to the ordinary non-technical user."

Fleming's contribution to photometry was exemplified by exhibits showing filament standards that he developed in 1896 to replace the pentane lamp and other flame standards. His work in electrical measurements included the development of the Fleming-Gimingham design of a dynamometer voltmeter in 1887, and of the Fleming-Clinton method of measuring capacitance. His work as a teacher was typified by a number of manuscript lecture notes, and by a reproduction of the original drawing of his mnemonic, well known to students as "Fleming's Right-Hand Rule."

Public Works Exhibition

No. II—(*Concluded from page 660, November 12th*)

THE Public Works Exhibition was opened at Olympia, London, last Monday and will end tomorrow. We conclude our description of some of the equipment shown.

E. Boydell and Co., Ltd.

A new 1 cubic yard capacity diesel engine-driven, hydraulically operated loader in the Muir-Hill range of machines made by E. Boydell and Co., Ltd., Old Trafford, Manchester, is shown in Fig. 9. This machine has a chassis main frame fabricated from rolled steel channel and partly in box section heavily braced for loader operations. A pivoted suspension system provides articulation between the front and rear axles and gives stability to the machine when on rough ground, as well as ensuring that the bucket is always presented on the same horizontal plane as the front axle.

The loader is driven by a diesel engine which develops 42 h.p. at 1750 r.p.m. and is fitted with a constant mesh gearbox giving six forward and two reverse speeds. Double-acting hydraulic rams operate both the jib and the bucket. The jib and frame are so designed that if desired when entering work, the load is taken by the main frame and not on the rams. The controls of the hydraulic system are grouped below a central steering wheel from which the driver has a clear view of operations.

The standard general purpose bucket has a full 1 cubic yard struck capacity and is 4ft 7in wide with a rated working load of 25 cwt. The discharge angle of the bucket and the digging angle of the bucket edge are both adjustable.

Alternative buckets available are a 2¼ cubic yard struck capacity bucket 6ft 3in wide for handling coke and similar light materials, and a heavy duty, ¾ cubic yard struck capacity quarry bucket 4ft 7in wide fitted with teeth for rock handling. A dozer blade can also be attached to the bucket for light work.

The machine has a maximum under-bucket-hinge clearance of 11ft 2in and a forward reach with the jib horizontal of 3ft 8in. Its approximate weight unladen is 4 tons 16 cwt.

Department of Scientific and Industrial Research

An automatic recording instrument for measuring the concentration of dissolved oxygen in a river is one of the exhibits on the D.S.I.R. stand. In the usual method for determining dissolved oxygen in a stream, samples are taken by hand and the concentration of oxygen in each is estimated by a chemical method. The oxygenation in a river, however, may fluctuate widely and rapidly and there is therefore a need for some equipment which will measure either continuously or at frequent intervals. The instrument developed by the D.S.I.R. takes samples of water automatically at ten-minute intervals and applies to them the Winkler method of analysis in which the end product is an iodine solution. When this method is used manually the amount of iodine present is determined by titration with a standard solution of thiosulphate but in the automatic apparatus the colour of the iodine solution is measured by a photo-electric cell. The result is recorded on a chart.

Two simple instruments for site measurements to control the quality of concrete are also to be seen on the D.S.I.R. stand. The "buoyancy meter," as it is called, measures the amount of water in damp aggregate or sand, so that an appropriate adjustment can be made to the water added to the mix. The sample is weighed in air and water to determine the percentage weight of water it contains. The second instrument—a compacting factor apparatus—is equally simple; it is used to check the uniformity of concrete workability. It consists of three containers, set vertically, the upper two having doors at their bases. A sample of mixed concrete is placed in the upper container and is allowed to drop successively into the other two. The concrete in the bottom container, which is a cylinder, is struck-off level and automatically weighed. The weight is registered on a dial in terms of its divergence from a target value, and the dial indicates directly the amount of water to be added to or subtracted from the nominal quantity of water in the mix.

Consolidated Pneumatic Tool Company, Ltd.

Amongst the air compressors and pneumatic tools shown by the Consolidated Pneumatic Tool Company, Ltd., 232, Dawes Road, London, S.W.6, there is a new design of portable rotary, two-stage, air compressor. The compressor is driven by a four-cylinder Rolls-Royce oil engine, developing 110 b.h.p. at 1775 r.p.m. It is to be made in four capacities with free air deliveries of 600, 365, 210 and 125 cubic feet per minute at 100 lb per square inch, the model exhibited being that of 365 cubic feet delivery.

Whilst the machine is in operation a copious supply of lubricating oil is delivered by a gear pump to the high and low-pressure rotary vane compressor units. This oil serves to lubricate and seal the vane clearances as well as to control the temperature rise of the air during compression. After passing through the compressor the atomised oil in the compressed air is removed in an oil separator and drains back into the main supply tank. After being filtered and cooled in a radiator the oil is recirculated by the gear pump. The makers state that the separation of oil from air is very complete, and oil consumption is particularly low.

Kwikform, Ltd.

A system of steel shuttering recently introduced by Kwikform, Ltd., Waterloo Road, Birmingham, 25, permits lifts of 6ft to be poured. It comprises a basic steel panel, 4ft by 1ft by 2½in deep, and weighing 36 lb. These panels are fastened on to steel soldiers by tee-headed bolts. The accompanying illustration, Fig. 10, shows the method of setting two assembled shutters the correct distance apart, and of holding them in position when the wet concrete is in place. As may be seen, the central assembly consists of two nuts welded to two steel rods. A square-threaded rod is screwed into each of the nuts, one on each side, and the shutters are adjusted to the correct distance apart by the screwed lugs bearing on the outsides of the soldiers. Three of these connections are fixed between each pair of soldiers when a 6ft lift is being constructed.

Kwikform, Ltd., is also showing a range of tubular scaffolding, including a newly introduced portal frame element, 4ft 6in high and 4ft wide, with open corner clamps, which eliminates the "threading" of the ledger. A mould for hollow concrete blocks, known as the "Autopress," is also exhibited. It is intended principally for use without the aid of casting yard plant such as vibrators. The mould weighs about 100 lb and its core is located on a platform on a short pedestal. The mould is filled, and the wet concrete pounded with the lid of the mould, which is fastened by a spring clip. Then a foot pedal is released and the mould drops to the base, thus giving a final consolidation to the concrete.

Fig. 9—One cubic-yard-capacity diesel-engine-driven, hydraulically operated loader

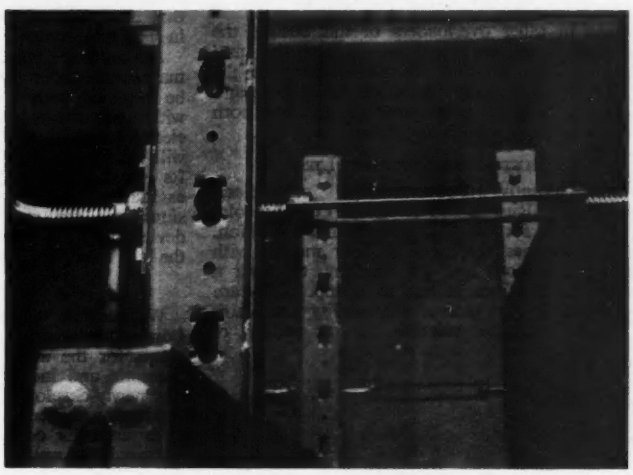


Fig. 10—Steel shuttering showing combined tie and spacer assembly

Mackay Industrial Equipment, Ltd.

There is displayed for the first time by Mackay Industrial Equipment, Ltd., Feltham, Middlesex, an Allis-Chalmers H.D. 9G tractor fitted with a 2½ cubic yards "Tracto-Shovel."

This tractor has a four-cylinder, two-stroke diesel engine giving 72 drawbar horsepower. The gearbox gives six forward speeds and three reverse. First gear gives a speed of 1·4 m.p.h. and a drawbar pull of 19,030 lb; second gear a speed of 2·1 m.p.h. and a pull of 12,240 lb; in sixth gear the speed is 5·7 m.p.h. and the top reverse speed is 4·4 m.p.h.

The clutch and brake steering, which for ease of operation is mechanically assisted, gives the tractor a turning radius of 14ft 7½in. The ground pressure with the standard 16in tracks is 9·71 lb per square inch To carry front-mounted equipment the tractor is built with an extra long track and truck frame, the truck frames being joined by a rigid beam in order to form a stable base.

The shovel equipment is operated by a hydraulic pump mounted at the front of the engine and controlled by a four-position control valve which is convenient to the driver's right hand. Both the lift cylinders and dump cylinders of the shovel are double acting, thus giving down pressure for excavating, a controlled dump speed and a quick return movement.

The bucket has a heaped capacity of 2½ cubic yards and a struck capacity of 2 cubic yards, its discharge height being 9ft 1in.

The new "Merton Overloader," exhibited has a ¾ cubic yard bucket which covers the full width of the front wheels of the tractor. The digging depth of the bucket can be adjusted to any position between 2in above ground level and 4in below ground level. To vary the discharge height a small hand winch is operated to raise or lower the overhead structure of the machine by extending and retracting telescopic rear upright members. The bucket can be discharged at any height from a minimum of 6ft 11in to a maximum of 11ft 2in.

The reach of the bucket, that is the distance from the inside edge of the bucket when in the discharge position to the rearmost part of the tractor, is 3ft 6in when in the minimum discharge position and 2ft when in the maximum discharge position. From the minimum discharge position the overhead structure can be lowered still further to the travelling position, giving the machine an overall height of 8ft 5in.

As in other overloaders of this design, the bucket is operated by means of winches and ropes. The winches are mounted above the rear wheels on each side of the driver's cab and are controlled by one lever which operates both the winch drive clutch and the winch brakes.

Ruston and Hornsby, Ltd.

The recently introduced "YC" class diesel engines of Ruston and Hornsby, Ltd., Lincoln, are shown for the first time at this exhibition. These engines are made in four models with two, three, four and six cylinders, to cover a power range from 16 h.p. to 72 h.p. They are designed to give ease of accessibility and maintenance and be suitable for a variety of

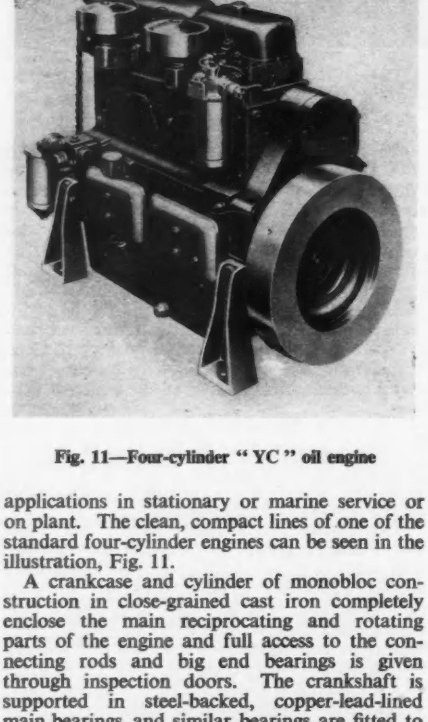


Fig. 11—Four-cylinder "YC" oil engine

applications in stationary or marine service or on plant. The clean, compact lines of one of the standard four-cylinder engines can be seen in the illustration, Fig. 11.

A crankcase and cylinder of monobloc construction in close-grained cast iron completely enclose the main reciprocating and rotating parts of the engine and full access to the connecting rods and big end bearings is given through inspection doors. The crankshaft is supported in steel-backed, copper-lead-lined main bearings, and similar bearings are fitted to the "H"-section connecting rods. Low expansion silicon-aluminium pistons, fitted with three pressure and two scraper rings, are fully anodised above the top scraper ring. A high-tensile cast iron crankshaft is gear-driven from the crankshaft at the flywheel end of the engine and operates the valves through push rods and rocking levers. The cylinder heads, carrying the overhead inlet and exhaust valves, together with the operating gear and injectors, are water-jacketed to ensure cool valves during running.

A separate fuel pump is fitted to each cylinder and is operated by a rocker lever from the camshaft. Multi-hole injectors are used and a filter is fitted on the suction side of the fuel pump.

Thos. W. Ward, Ltd.

A tower crane of French design exhibited by Thos. W. Ward, Ltd., Sheffield, is, on account of roof height restrictions, built up to a height of 62ft, but this can be extended by the easy addition of sections to a height of 101ft 6in. The crane has a maximum radius of 52ft 6in and will lift 1763 lb at 52ft 6in radius, 2204 lb at 42ft 6in radius, and 4408 lb at 23ft radius. Its hoisting speed is 164ft per minute in high gear and 52ft 6in per minute in low gear, whilst the slewing speed is 1 r.p.m. The crane is built on a travelling base, which houses the winch and driving motor, and runs on a 7ft 6in track. It can be driven either by an 18/20 h.p. diesel engine or a 16/17 h.p. electric motor.

The crane is easy to transport and erect, and its base can be fitted with pneumatic wheels for towing behind a lorry which carries the jib and column sections. It is claimed by the makers that the crane can be erected by five workmen in sixty man hours.

A builders' hoist which is shown can be manœuvred and positioned by one man and can be supplied with a single or double barrow, with alternative petrol or diesel engine or 3-phase electric motor drive. The single barrow machine will lift 10 cwt and the double barrow 8 cwt. Its standard delivery height of 20ft can be extended to 84ft by the addition of 8ft extensions and the machine is fitted with safety devices to prevent over running at the top or the load from falling in event of rope breakage.

Wallace and Tiernan, Ltd.

Wallace and Tiernan, Ltd., of Power Road, London, W.4, is exhibiting plant and instruments for the application of chemicals in the domestic and industrial fields. One exhibit is the newly-developed "Silactor" for accurate production and feeding of chlorine activated silica. It is used for coagulation and sedimentation of turbid raw waters. The addition of activated silicon in such treatment promotes better flocculation. The instrument provides a continuous process of silica activation and reduces handling of chemicals to a minimum by using them direct from the suppliers' containers. A second exhibit shows a typical layout for automatic dechlorination and residual chlorine control in the treatment of water supplies.

Petbow, Ltd.

A gas turbine powered generating set, which develops 50kVA and weighs less than 1000 lb, is exhibited by Petbow, Ltd., Sandwich, Kent. The advantage of the gas turbine in such applications as this one is principally its lightness. The Rover 60 h.p. turbine, which weighs 120 lb, is used; the turbine was described in our issue of April 9, 1954. The alternator has been developed by Petbow, Ltd., in association with the Macfarlane Engineering Company, of Glasgow. It is driven directly from the turbine at 3000 r.p.m. A high output/weight ratio has been achieved by making the alternator of all aluminium construction. It generates at 440V, three-phase, giving 40kW.

Thomas Storey, Ltd.

The Bailey bridge of wartime fame is finding diverse applications in civil engineering projects, as is well exemplified by the stand of Thomas Storey, Ltd., Vernon Works, Stockport. It is perhaps a commentary on the success of the original Bailey bridge that its adaptation to peacetime uses has necessitated virtually no structural modification. One modification has, however, recently been introduced. The Bailey panels are connected together by steel pins, which engage in the panels with a clearance of $^{1}/_{32}$in. Over a considerable span, such connections allow a certain deflection in the completed structure, and in some applications, particularly where live loads are involved, such as those where the bridge carries crane rails or conveyors, a greater degree of rigidity is required. This requirement has been met by using a composite pin which gives a tight fit. The new pin comprises a hollow split sleeve, and a tapered central plug. The sleeve is fitted in, with the customary clearance, and then expanded by hammering in the central part.

George Pike, Ltd.

We illustrate below (Fig. 12) a wheel-mounted power saw, which is one of the exhibits on the stand of George Pike, Ltd., Alma Street, Birmingham, 6. The saw, which is known as the "Treehog," is designed for operation by one man. As the illustration shows, it consists of a petrol engine—a Villiers 5 h.p. engine working at 2500 r.p.m.—which drives a shaft assembly mounted in steel tubing at the front of the machine and carrying the saw blade. The blade is 30in in diameter; it can be adjusted to a vertical, a horizontal or an intermediate position by a clamping lever positioned at the centre

Fig. 12—Pike saw

of the tubular arm assembly, and a locking pin, and indexing plunger and handle mounted above the wheel. The saw spindle is mounted on thrust and self-aligning roller bearings, and the transmission is through two "V"-belts, acting as a slipping clutch, and a hollow shaft on roller bearings, to bevel gears in the head.

The firm is also exhibiting a "jet conveyor," an item of plant which collects material—such as excavated "spoil" or sand—between two fast moving belts in such a manner as to throw it for a distance of 10ft to 70ft. Its capacity is 60 tons per hour, the "jet" of materials reaching a maximum height of about 30ft. Generally, the firm states, abrasive or sharp materials should not be used with the conveyor unless the savings in time and labour offset the replacement costs due to wear. The jet conveyor is powered by an engine of 5–8 h.p.

M.E. Engineering, Ltd.

An electro-pneumatically operated hammer of Italian origin—the Simbi 4R hammer—is shown on the stand of M.E. Engineering, Ltd., 457, Finchley Road, London, N.W.3. The hammer is operated by an electro-magnet and a return spring, through a transformer and voltmeter and frequency reducer supplied with it, giving an operating voltage of 42V, from 50 c/s supplies at 110/220V or 380V. The hammer gives 3000 blows per minute, and its power is 200W. Various tools, such as chisels and concrete vibrator paddles, can be fitted to it.

Conversion Tables.—A set of tables for the conversion of pounds to kilogrammes is being issued, free, on application, by Davidson, Park and Speed, Ltd., 91–93, Bishopsgate, London, E.C.2. The tables cover the range of 1 lb to 1 ton in steps of 1 lb, giving the kilogramme equivalents and also the hundredweight, quarter and pound equivalents. Further tables cover the range of 1 ton to 100 tons, and the metric equivalents of a number of Imperial units.

Rowridge Television Transmitting Station

A REGULAR programme service from the new television transmitting station at Rowridge, Isle of Wight, was inaugurated by the B.B.C. on November 12th. The new station operates on "Channel 3," vision 56·75 Mc/s, sound 53·25 Mc/s.

It is built on a 26-acre site 470ft above sea level, 3½ miles west-south-west of Newport, near the Calbourne road, and is the first of the five medium-power stations to be equipped with permanent transmitters as part of the B.B.C.'s eighteen-station plan to provide a television service for 97 per cent of the population of the United Kingdom. Initially, Rowridge will use a temporary mast and aerial, and its service area will be somewhat less than that expected when the permanent mast and aerial system are brought into use next autumn. However, it is expected to provide a reliable service to approximately 2,000,000 people.

The station building, which is reached by an approach road 1¼ miles long, is brick built with a granite roughcast finish and Portland stone relief. The flat roof is constructed from pre-cast concrete beams, and the floors are mainly of concrete, provided with ample cable and pipe ducts, and covered with cork or linoleum tiles. All internal doors are oak-faced flush panelled, and all window frames and external doors are of metal.

The main vision transmitter, manufactured by Marconi's Wireless Telegraph Company, Ltd., is of the low-level modulated design with a peak-white output of 5kW. Modulation is carried out at the 500W level and the signals are then amplified by two class B wide-band linear r.f. amplifiers, each using a pair of forced-air-cooled triodes (type "BR 191"), made by the English Electric Company, Ltd. The appropriate shaping of the vestigial side-band signals radiated by the vision transmitter is carried out entirely by its own tuned circuits, and not by a separate vestigial side-band filter. The valve filaments are a.c. heated, with the exception of those in the modulated amplifier and the linear amplifiers, which derive their supply from metal rectifiers. H.T. supplies for the transmitter are taken from hot-cathode, mercury-vapour rectifiers, which provide a maximum of 3kV for the anodes of the linear class B amplifier stages.

The sound transmitter was also manufactured by Marconi's Wireless Telegraph Company, Ltd. It is a conventional class B modulated equipment and is rated at 2kW output. The output power will be adjusted to 1·25kW to maintain the standard ratio of 4 : 1 in terms of vision to sound power. All valve filaments are a.c. heated. As in the case of the vision transmitter, the crystal-controlled drive and the power conversion equipment are built as an integral part of the transmitter.

Both transmitters are contained in similar sheet steel cubicles mounted side by side to present a single continuous front in the transmitter hall. The air blast cooling equipment and combining filter are mounted behind the transmitter cubicles, which are built into a soundproof partition wall, so as to isolate the noise of the air blowers from the control desk situated in front of the transmitters.

Both sound and vision transmitters are controlled and monitored from this desk, which incorporates a built-in waveform monitor and two picture monitors besides the conventional controls and meters. The provision of the two picture monitors enables the incoming signals to be compared with those radiated. Programme switching for both sound and vision circuits is accomplished at this desk. The controls of each transmitter are sequence-interlocked to ensure that the various supplies are applied in the correct order and, where necessary, with the appropriate time interval between each. Next to the control desk are the vision and sound programme input equipment bays, and the test waveform generating equipment which provides a variety of signals for testing, lining up and maintaining the characteristics and performance of the vision transmitter.

The low-power standby transmitters that are shortly to be installed at Rowridge will operate on the same frequencies as the main transmitter and will have a rated power output of 500W vision and 125W sound. They will be manufactured by Standard Telephones and Cables, Ltd.

From London the vision programme reaches Rowridge via a Post Office repeater station at Alton in Hampshire, where special receivers intercept the vision signal radiated from Alexandra Palace. The signal is then re-radiated by a microwave link transmitter and is received by Post Office equipment installed at Rowridge; here the video signal is passed to the B.B.C. vision input equipment.

Ultimately, two microwave links will be available, one normally acting as spare to the other, and they will be reversible so that outside broadcasts from the Isle of Wight may be relayed to the mainland for connection to the main television distribution network.

Special G.P.O. telephone circuits, including a submarine cable between Southampton and the Island, carry the sound programme to Rowridge.

The receiving aerial and reflector for the Alton–Rowridge microwave vision link are at the 60ft level on the temporary 200ft self-supporting tower. This tower also carries the two dipoles forming a simple two-stack array which serves as the temporary vision and sound-transmitting aerial for Rowridge pending completion of the permanent mast and aerial system. They are mounted at the 175ft level, whilst at the top are the aerials for receiving the television programmes from the high-power transmitter at Wenvoe, should the normal programme route fail. The permanent 500ft mast will carry an aerial system of greater vertical directivity and will provide greater field strength and coverage.

Power for the station is taken from the Southern Electricity Board's 11kV network over a feeder from Swainston. It is transformed on site to 415V, three-phase, 50 c/s, by means of a 200kVA delta-star-connected transformer. Supplies for the transmitters and the programme input equipment are obtained through regulators which provide a constant voltage, ±1 per cent, irrespective of normal mains fluctuations.

In the event of mains failure, supplies can be taken from a stand-by set consisting of a 32kVA, 240V, 50 c/s, single-phase diesel alternator. It is arranged to start up automatically, should the S.E.B. supply fail, and would provide power for the vision and sound input equipment, the low-power standby vision and sound transmitters and certain essential lighting.

Because the station is some 3 miles from the nearest water main all water has to be carried to the site in tankers. They fill a 2000-gallon underground tank from which the water is automatically pumped to two 750-gallon high-level tanks in the building by means of electrically driven pumps, controlled by float switches.

When the new station is equipped with its permanent aerial and mast it will serve an area covering the whole of Hampshire and parts of Dorset, Wiltshire and West Sussex. This area will include some 2,600,000 people; the range with the temporary aerial installation may in certain directions be some 10 to 20 miles less, but even so the population coverage will be approximately 2,000,000.

Principal Contractors

Plant.—Vision and sound transmitters and associated equipment, Marconi's Wireless Telegraph Company, Ltd.; reserve transmitters, Standard Telephones and Cables, Ltd.; low-voltage switchgear, English Electric Company, Ltd.; wiring, Southern Electricity Board; coaxial cables, Telegraph Construction and Maintenance Company, Ltd.; emergency power plant, Dale Electric (Yorkshire), Ltd.

Civil Engineering.—Roads and buildings, Westridge Construction Company, Ltd.

Programme Links.—Tower erection at Rowridge, Carter-Horseley (Engineers), Ltd. The Post Office was responsible for the installation and overall line-up of the link and also for the design and manufacture of the associated control equipment.

Boundary Layer Control

By Dr. Ing. G. V. LACHMANN, F.R.Ae.S.*

No. I

In this very significant paper, which was read before the Royal Aeronautical Society on Thursday, November 11th, the author discusses the principles and the methods of application to aircraft of boundary layer control, both for the purpose of increasing the lift and for obtaining laminar flow. In the first part the author discusses methods of preventing by boundary layer or circulation control the separation of flow from the surface of an aerofoil and their application to existing aircraft using modified flaps. The second part is concerned with the attainment of laminarisation through distributed suction of the boundary layer. In both forms the author provides a brief historical review of the theory, research and application undertaken in different countries. The paper is confined to non-classified reports. The author maintains that the practicableness of this integration of engine power and lift has now been fully established and that much leeway in flight development has to be made up in this country. With the modest achievement of only 50 per cent laminarisation, the thrust requirements are halved, range is increased by 45 per cent, and optimum cruising height reduced by 14 per cent.

It has almost become a tradition in recent years to begin a paper on boundary layer by paying a tribute to the great Prandtl and his famous paper, in which he introduced the conception of boundary layer into fluid dynamics.

The year 1954 is, however, not only memorable to mark the passing of fifty years since Prandtl's classical demonstration of the effect of boundary layer suction on the flow pattern around a cylinder; it is also memorable because in this year most convincing demonstrations of practical applications of boundary layer control for aircraft have taken place. I am referring, in particular, to the demonstrations with the Attinello flap in the United States which mark the introduction of one form of boundary layer control as an engineering and practical reality.

In coming years the present period in aviation may well be recognised as one where an important evolution of design philosophy took place.

In recent years a new school of thought has been growing up leading away from the classical conception of the aeroplane where the power plant serves solely for the production of thrust to pull the lift producing wings through the air.

The new conception aims at a closer integration of power plant and wings and at harnessing the power plant to the combined task of lifting and propulsion.

This conception has been stimulated by the introduction of the gas turbine and, broadly speaking, the evolution is one leading away from the motorised glider as pioneered by the Wright Brothers to what might be termed a "winged turbine."

The new philosophy has many branches and is not confined to fixed-wing aircraft. The extreme manifestation of this philosophy is the production of lift directly without the intermediary of circulation (flying bedstead).

Another branch of this new outlook consists in by-passing a small proportion of the available power for controlling the boundary layer and the circulation around the wings.

Modern methods of boundary layer control for the purpose of preventing separation are based on the principles of either infusing kinetic energy into the flow, or by removing boundary layer through suction.

The possibility of laminarising a boundary layer through suction was first envisaged by Griffiths and Meredith in 1936, but the first experiments were negative. The same theoretical conclusions were reached, a few years later, by Holstein in Germany, who succeeded in demonstrating the possibility of laminarising the boundary layer through suction.

While research workers in many countries became fascinated with the idea of developing methods of boundary layer control, both for the purpose of lift increase and laminarisation, the majority of aircraft designers were inclined to consider any suggestions of boundary layer control as purely academic and impracticable.

With the introduction of the gas turbine for

* Director of Research, Handley Page, Ltd.

aircraft propulsion, the practical outlook has changed decisively since now a useful reservoir of compressed air exists for directing a jet of air into the boundary layer, or for energising suitable suction devices. Besides, the introduction of swept-back wings, thin aerofoils and increasing wing loadings have emphasised the the need for higher lift coefficients than were hitherto available with conventional methods.

1. Boundary Layer and Circulation Control Through Blowing and Sucking

General Principles and Definitions.—I propose to deal first with the application of boundary layer control to prevent separation of flow from

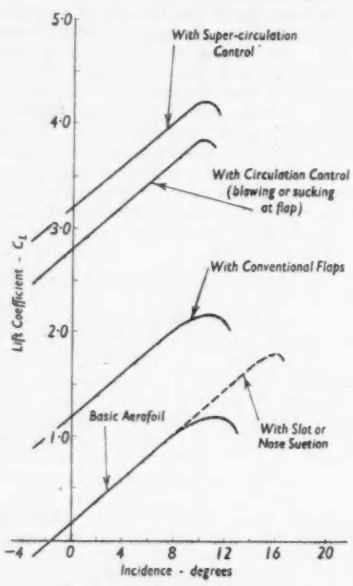


Fig. 1—Generalised lift curves

the surface of an aerofoil—for example, at the sharp nose of an aerofoil of small thickness/chord ratio.

By preventing separation and premature stall the lift increase will continue to larger angles of attack than for the ordinary section.

The slotted wing exemplifies the first practical form of an automatic boundary layer control.

Boundary layer, which is formed over a slat at the leading edge, flows off at its trailing edge when the slot opens, and the secondary flow through the slot prevents this separated boundary layer from interfering with the flow over the main wing.

The circulation formed around the slot (in the open position) reduces the pressure gradient over the nose of the main wing and makes it, therefore, easier for the boundary layer to flow

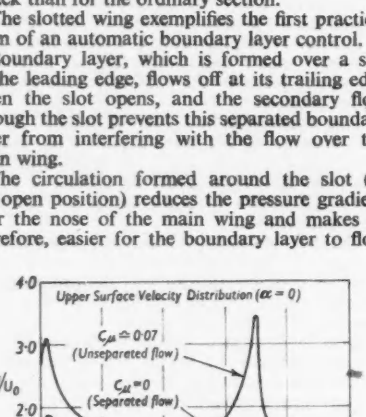


Fig. 2—Pressure distribution over upper surface of a flapped aerofoil

over it without separating from the surface. Equally well. separation is delayed on the slat itself, since here, too, the pressure gradient from slat leading edge to slat trailing edge is reduced, the latter being placed in the low-pressure region which occurs over the nose of the main wing.

The slotted flap improves the ordinary flap in the same manner, by delaying separation at the flap hinge and by allowing a higher circulation to develop over the part of the wing ahead of the flap, which fulfils the role of the slat.

The stream of air coming from a slot has the same effect as a jet pump and infuses kinetic energy into the boundary layer. The tendency of the flow to separate from the wing surface depends on whether the retarded boundary layer air is entrained in sufficient quantities into the main stream.

This conception of the slot effect led Professor A. Baumann to the method of blowing out a stream of air at suitable points on the upper side of the wing to accelerate the boundary layer. While in the case of a slotted wing the velocity of the secondary flow through the slot is limited by the pressure difference between upper and lower surface, with blow-out the velocity of the secondary stream of air can be chosen at will. Otherwise, there is no fundamental difference between the two methods.

Separation can thus be prevented either by established methods of slots or nose flaps, or, alternatively, by removing excessive boundary layer by suction through porous material or through a suction slot near the leading edge, or, alternatively, by infusing kinetic energy into the boundary layer and improving the process of entrainment by blowing air out tangentially to the surface contour.

By preventing separation at the leading edge and premature stalling of the wing the linearity between lift and angle of incidence can be continued to larger angles of incidence (Fig. 1).

The classical method of circulation control, in contrast to extending the usable range of the lift curve, is the trailing edge flap. When an ordinary type of trailing edge flap (slotted or unslotted) is deflected at constant angle of incidence, circulation will increase and the lift curve will shift to the left in Fig. 1.

However, the observed increment ΔC_L due to large flap angles will be substantially less than one would expect from the application of Glauert's theory for hinged flaps. The reason is the peculiar pressure distribution with strong adverse pressure gradients on the upper surface of the aerofoil leading to separation of the boundary layer (Fig. 2). The actual pressure distribution which will normally develop is shown in dotted lines.

Separation at the flap can be prevented either by sucking away boundary layer near the flap hinge, or by blowing a jet of air through a slit ahead of the flap. The Coanda effect makes this secondary flow adhere to the curvature of the flap nose and entrains the retarded air in the region of separation.

Thus it is possible to bend the flow over the flap and to achieve the lift increase ΔC_{LT}, which theory predicts for a flap of equal flap/chord ratio and flap angle.

[The author then briefly reviewed developments of boundary layer and circulation control for high lift in various countries. It indicated the large contribution made by Germany, particularly at Gottingen, from 1930 to 1936 with wind tunnel research and the application of different blowing or sucking systems to military aircraft in the last war. Details were given of the considerable progress made since the war in America. An analysis followed of take-off and landing considerations.]

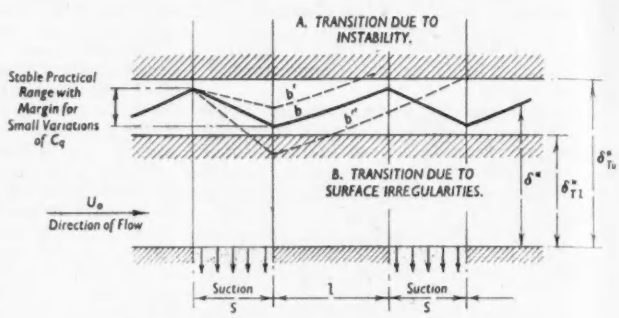
Summary.—In judging the applicability of boundary layer or circulation control to existing aircraft, or potential aircraft of the future, the most obvious application is for deck landing aircraft and a new type of short-haul passenger aircraft characterised by very short take-off and landing runs of the order of 500ft over a 50ft obstacle, with correspondingly very low landing and take-off speeds, which would enable such aircraft to operate from very small aerodromes.

All swept-wing aircraft, either in the subsonic or supersonic class, would benefit from the higher lifting capacity due to circulation control and the flap construction would be simpler and lighter than conventional high lift flaps.

The choice of maximum lift coefficients for take-off or landing depends on thrust and span loading of the design, and should be considered simultaneously with the power plant.

Blow-out is the simplest method from the engineering point of view, but much heavier on mass-flow than either the suck or suck-blow method, where the installation may be a little more complicated.

Generally speaking, although wind tunnel research has by no means become redundant, the accent of importance has decisively shifted to the engineering and installation side. The practical success achieved with boundary layer control in the United States was due in the first place to the determined efforts to tackle the " plumbing " and to undertake flight research on suitable aircraft.



b—Boundary layer growth within stable range.

b'—Boundary layer growth with insufficient suction. (Premature transition due to instability.)

b''—Boundary layer growth with excessive suction. (Premature transition due to roughness.)

Fig. 3—Mechanism of boundary layer suction through discrete strips of porous material

In both respects a good deal of leeway has to be made up in Great Britain.

Laminarisation Through Boundary Layer Control

[At this stage the author gave another historical review of the theory and experimental research undertaken in different countries. It was restricted to suction methods and published and non-classified reports. He then went on to consider at length some basic aerodynamic considerations and the effect of wing surface characteristics on the behaviour of the boundary layer.]

Methods of Laminarisation

There are two basic methods which have been tried out, namely, distributed suction and suction through discrete sinks. The latter method was first used by Holstein and later by Pfenninger and by various research workers at N.A.C.A., and the sinks were usually constituted by narrow slots where a favourable sink effect was utilised. Distributed suction through a porous skin was used at the N.A.C.A. by Braslow and Visconti, and also by Sir Bennett Melville Jones and Head, who used nylon and rolled gauze, heavily electroplated.

The argument put forward in favour of slots is that diffusor shaped slots enable a certain recovery of pressure, while with suction through porous material, a complete loss of dynamic pressure takes place. Slots, however, are difficult from the manufacturing point of view, especially the maintenance of the correct minute width. In model tests it was observed that they required frequent honing to keep the edges sharp.

Distributed suction is the closest approach to the ideal theoretical method of an asymptotic boundary layer, but it is probably the most difficult method from a practical point of view.

The author introduced the method of sucking through discrete strips, which is a compromise between the two basic methods. These strips can be either of porous material or they can consist of rows of perforations.

In order to get a qualitative appraisal of the mechanism of laminarisation, and to define the essential design parameters, consider suction

through two porous strips of width S separated in chordwise direction by distance l (Fig. 3).

The zig-zag line b represents the change of thickness of stable boundary layer. Reduction of boundary layer thickness occurs while boundary layer is withdrawn through the spanwise sink (negligible sink effect is assumed), followed by a build-up of thickness during the passage from one strip to the next. Upper and lower limits of the stable range are marked by δ_{Tu}^* (upper limit) and δ_{Tl}^* (lower limit). The upper limit is determined by stability considerations (Tollmien-Schlichting type instability) and the lower limit by transition due to surface roughness.

Dotted lines b and b'' indicate the effect of either under-sucking or over-sucking.

Over-sucking leads to transition due to roughness effect and insufficient suction leads to instability.

It is obvious that closing up the distance of strips (reduction of l) ensures stability with reduced local suction and less reduction of boundary layer thickness.

Hence, relatively greater surface roughness becomes tolerable for the same value of U/ν. If the strip spacing is reduced more and more, eventually the case of distributed suction is attained.

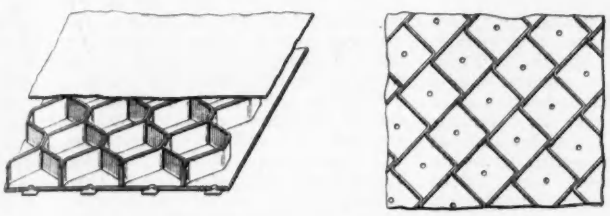


Fig. 4—Method of constructing a skin surface according to British Patent Specification 687,723 (Head)

According to this, one should expect higher values of U/ν for a stable flow with distributed suction than for strip suction, surface roughness being the same in both cases. This seems to be confirmed by the experiments of Braslow and Visconti with a model of 64A010 aerofoil having a porous bronze skin, where the remarkably high value of $U/\nu = 5 \times 10^6$ was measured.

On examining boundary layer profile and thickness at the upstream and downstream edges of a suction strip, it will be found that profile I approaches more and more the ordinary Blasius-type as distance S between strips widens, while the profile II will generally be found more convex and almost identical with the profile of an asymptotic boundary layer.

Reducing strip distance results in improvement at both ends of the range, profile I approaching the more stable shape of profile II, and boundary layer thickness becoming more evenly distributed.

According to Fig. 3, a narrow range of stable laminar flow is possible between an upper and a lower limit. The upper limit could be defined by a critical value of $(R_\delta^*)_{crit}$.

Comparison of $(R_\delta^*)_{crit}$ for a wing with suction applied through spanwise sinks and for one without suction, but having a zone of laminar flow due to a favourable pressure gradient, showed reasonably good agreement but the agreement between the values of $(R_\theta)_{crit}$ (Reynolds number (based on momentum thickness)) was much closer.

A very conservative value for $(R_\theta)_{crit}$ based on wind tunnel experiment is 1250, including roughness effect.

Some Practical Design Considerations

Design of Suction Surfaces.—Essential requirements, according to the foregoing, are :—

(i) Local surface roughness should be less than half local boundary layer displacement thickness.

(ii) Waviness should be $<0{\cdot}003$in within a 3in curvature gauge (to satisfy flight at $U/\nu \leqq 2{\cdot}5 \times 10^6$).

(iii) Pressure drop through the suction surface should be greater than pressure variations in spanwise or chordwise direction on the surface (to prevent outflow).

(iv) Reynolds number $\chi = \dfrac{|U\beta|_{max}\delta}{\nu} \leqq 125$ where $U\beta$ component of flow velocity perpendicular to outer streamline.

δ = boundary layer thickness.

In addition to these aerodynamic desiderata there are the additional requirements that the suction surface should not increase appreciably the weight of the wing structure, and it should not require excessively costly or difficult maintenance.

These are, indeed, formidable engineering requirements.

However, experience in many fields of engineering has proved that the major step towards the solution of any technical problem is clearly and exactly to recognise and analyse the important parameters and to specify requirements accordingly.

It will be understood that I cannot disclose in this paper the latest ideas or methods of how to achieve an engineering solution for a suction surface. However, some basic principles are disclosed in recently published British Patent Specifications (No. 687,723 (Head) and No. 713,426 (Lachmann and Handley Page, Ltd.)). The first specification (687,723) discloses a method of constructing a suction surface suitable for the application of distributed suction (Fig. 4). It comprises an inner skin of non-porous material (sheet) and an outer skin of porous sheet material, separated by an interspace and interconnected by a lattice of web members extending across the interspace and subdividing it into a number of non - intercommunicating cells, each of which communicates through an opening in the inner skin with a chamber, which is common to a number of such cells and to which suction can be applied.

The opening in the inner skin may be provided with a non-return valve and has an effective area and discharge coefficient that when flow takes place through the pores of the outer skin, and through the opening, the loss of head through the latter is considerably greater than through the porous outer skin.

The elastic moduli and gauge thicknesses of the materials used are such that under any condition of loading to which the skin may be subjected the outer porous skin is lightly loaded relatively to the inner skin and cell-forming lattice.

The non-return valves are visualised in the form of simple flaps of flexible non-porous material.

The necessity for non-return valves or equivalent devices arises from the necessity to avoid strong in and outflow tendencies with suction inoperative. Outflow due to chordwise pressure difference causes thickening of the boundary layer and substantial increase of profile drag and premature stalling in such flight conditions where no suction is applied.

A similar method for the application of distributed suction is disclosed in Specification 713,426 (Fig. 6), where the surface comprises an inner load carrying sheet having perforated recessed areas separated by exterior ridges milled from the inner sheet and integral with it, and a continuous substantially unstressed porous outer surface stretched over the inner skin and attached to the ridges.

The structural element comprises a corrugated sheet member and a second skin. Thus ducts are formed for the air sucked from the boundary layer within this sandwich panel without the expenditure of non-stressed material.

Further applications of the principle of integrating a non-stressed porous member to a skin panel incorporating the suction ducts as load-carrying members are illustrated in Fig. 5.

These applications refer to the method of suction through discrete suction strips of porous material spaced at chordwise intervals with portions of impervious skin in between.

Porous strips are inserted in the outer skin by means of a sliding fit, with the shear flow in the outer skin by-passing the porous strip so as to leave it substantially unstressed.

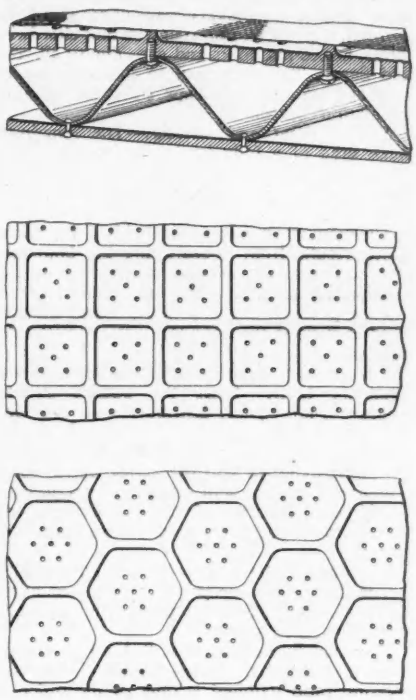


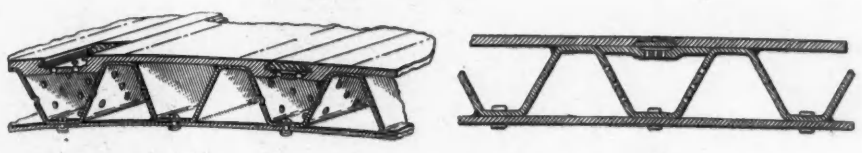
Fig. 6—Method for distributed suction according to British Patent Specification 713,426

A form of construction is also disclosed where closely spaced perforations in the outer continuous skin replace the inserted porous strips, and where an element of suitable diffusing material could be inserted below the perforations in case the pressure drop through the perforations was insufficient to prevent local in and outflow through the holes in the outer skin.

Both patents quoted were applied for in 1950. Broadly speaking, the principles disclosed have been found feasible methods for the construction of suction surfaces. However, a good deal of effort has been devoted since then to translating these basic methods into a suitable form of "hardware."

The high degree of surface smoothness is difficult to achieve and requires a good deal of very accurate workmanship, and often a lot of "elbow-grease," if the application to orthodox methods of wing construction is attempted.

I feel, therefore, that one has to look forward to novel forms of construction. Such unconventional methods may lead to the use of prefabricated sheaths in plastic material incorporating a suitable type of porosity, bonded to the upper surface of a metal panel in sandwich con-



(a) (b)

Fig. 5—Suction surface with porous strips inserted in the outer skin and suction surface with closely spaced perforations in the outer continuous skin. British Patent Specification 713,426

struction, utilising stress-carrying members as ducts.

The double-skin sandwich panel has the added advantage of providing a firm outer surface well supported by the internal duct members and with reduced tendency to develop surface waviness.

To reap the greatest benefit from laminarisation, the affected surface should be as large as possible and there seems to be no fundamental reason why, ultimately, the fuselage surface should not be laminarised as well as the wings.

The wing surface should be smooth over the greatest possible spanwise and chordwise extension. Engine and undercarriage doors should be avoided, if possible, also spanwise and chordwise joints, inspection doors and gaps due to ailerons and flaps. This may lead to the replacing of standard ailerons and flaps by some form of circulation control.

Suction Plant and Ducting.—The remaining wake drag of a fully laminarised wing is very small and can be reduced to zero by accelerating the boundary layer somewhat above free stream velocity.

The main effort is concentrated in pump work, which results from re-energising the boundary layer to free stream velocity (or above) and from overcoming external suction on the wing and making good duct and pressure losses encountered in sucking the boundary layer through the porous surface.

The primary item is re-acceleration of the boundary layer. Since the outside suction pressure is not equally distributed over the wing it obviously pays to have a graded suction pressure multi-stage pump. Detailed investigations have indicated that the saving due to using a multi-duct system with graded suction pressure would be of the order of 15 to 18 per cent, and that it would not pay to apply more than three stages.

It is obvious that the problem of grading flow resistance through the porous surfaces to avoid outflow is simpler with discrete porous strips than with distributed suction.

The suction compressors themselves should offer no particular design problem, since the pressure ratio required is only of the order of 2·5–3. A subsonic axial-flow compressor of three stages, aspirating air sumultaneously at each stage from different pressure levels, would seem to be a practical solution.

It seems fairly obvious that the boundary layer air should not be passed as working fluid through the turbine, but the latter aspirating ram air through its compressor should drive a separate boundary layer compressor.

Preferably the compressors should be driven by direct power take-off (shaft drive) from the turbine rotors, or by separate gas turbines fed by the main engines or, generally speaking, by gas or compressed air generators.

If the turbines driving the boundary layer compressors are near to the engines "hot gas" ducting might be considered.

An alternative would be "cold ducting" from the main compressors to separate combustion chambers of the auxiliary turbines driving the suction compressors.

(To be continued)

Turret Lathe

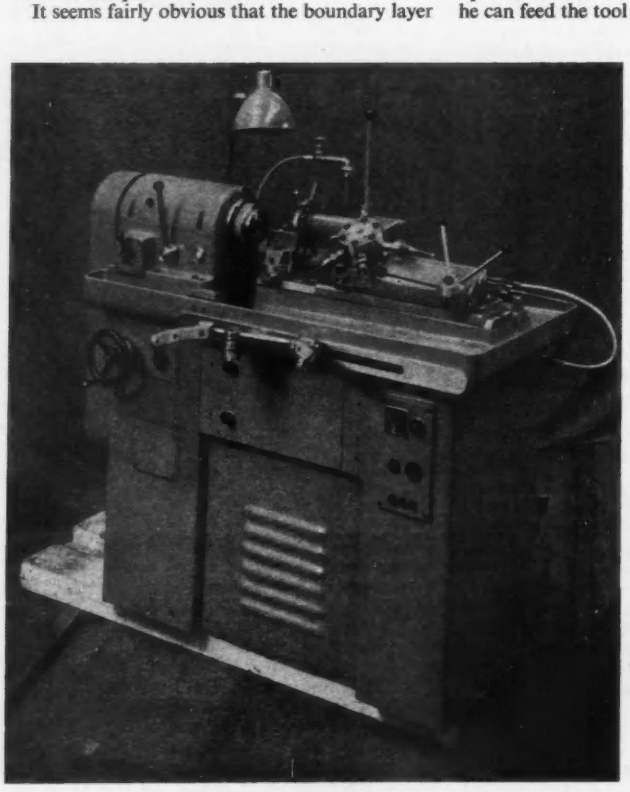
THE turret lathe shown in the accompanying illustration is an improved and larger capacity machine of a design introduced a few years ago by the Swiss Industrial Company, of Neuhausen, Switzerland. It swings work up to a maximum diameter of 3⅛in and 7 1/16in long, and when using collets takes bar up to 1⅜in diameter or with chuck work up to 1½in diameter.

The cabinet bed of the machine, in which the drive and electrical control equipment is totally enclosed, supports a rigid bed with two slides. The capstan slide is provided with a six-tool capstan head which can be indexed manually or automatically, and has a working stroke of 5⅞in. A second longitudinal slide at the rear of the capstan slide carries a transverse slide, also fitted with a six-tool head, and its transverse infeed movements and longitudinal movements are controlled by adjustable stops. Whilst the transverse slide tools are in use they are firmly supported by a vertical plate mounted close to the spindle nose on a heavy base on the main table. This tool support can also be used for the mounting of a template used in profile copying.

The transverse slide is moved longitudinally in respect to the work by the operation of a "hip lever," which consists of a bar along the front of the machine with two curved pad arms between which the operator stands. Whilst the operator moves the slide along by the hip lever he can feed the tool into the back of the work by means of a hand lever, or operate the handle of the longitudinal capstan slide carrying the drilling, boring, &c., tools. His other hand is thereby left free to operate the speed control lever or collet lever.

The headstock spindle is driven by a two-speed motor through a variable-speed gear unit, giving speeds from 60 to 3000 r.p.m. in two ranges of 60 to 480 r.p.m. and 410 to 3000 r.p.m. The spindle is carried in taper roller bearings and has a bore of 1·378in when using collets or 1·575in when a three-jaw chuck is used.

These machines are marketed in this country by Dowding and Doll, Ltd., 346, Kensington High Street, London, W.8.



Turret lathe, with longitudinal slides for the six-tool capstan head, and a six-tool head on a transverse slide at the rear

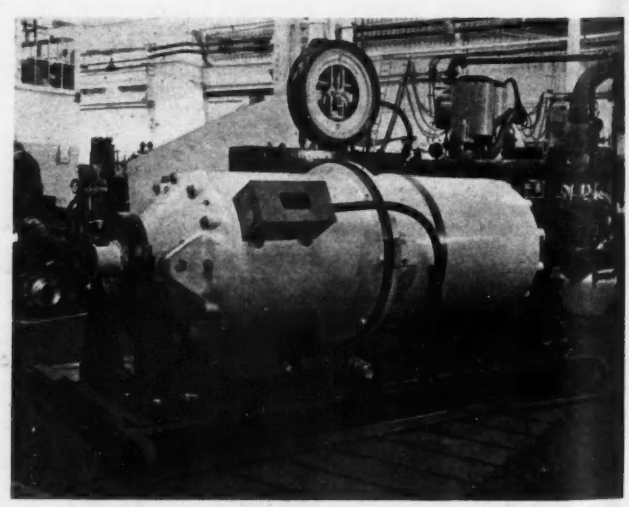
Submersible Pump Sets

THE modern tendency towards more powerful submersible pump sets has greatly aggravated the problem of starting. In sets of 200 h.p. to 450 h.p., built for 440V or 550V, three-phase operation, the direct-on-line starting current can reach six times the full load current. In order to avoid such peaks, the supply voltage has to be reduced, e.g., by an auto-transformer with on-load tap-changing. Unfortunately, the capital cost of a transformer is high, and for sizes above 350 h.p. there are in addition design difficulties.

The natural solution was to design the motors for a higher mains voltage. This raises the question of insulation, but as with medium tension motors, special grades of P.V.C. were again found to be satisfactory. The higher operating voltage allows direct-on-line starting without excessive peak currents. A typical set, for instance, is powered by a 350 h.p., 3000/3300V, four pole motor, and pumps water at the rate of 1000 g.p.m. against a 775ft head. It is stated that this set has a ratio of starting current/full load current of 2·3, while the starting torque is 43 per cent of the full load torque. There is a saving in the cost and weight of the feeder cables because of the reduced copper section, and resistance losses are decreased.

We recently had the opportunity of visiting the works of Hayward-Tyler and Co., Ltd., Luton, Beds, where we saw a newly-completed 1000 h.p., 3000/3300V, 50 c/s submersible motor. The accompanying photograph shows this unit arranged to serve as a dynamometer motor for testing the firm's centrifugal cargo pumps. It is stated that the diameter of a high-tension motor is somewhat larger than the corresponding medium-tension design, mainly because of the increased number of stator turns which have to be accommodated. The increase in winding space is not compensated by the reduction in the copper section, for this is counterbalanced by the need for heavier insulation.

The plain bearings and the thrust bearing are water lubricated and cooled. Running-up to 1475 r.p.m. is said to take two to two-and-a-half seconds; the ratio of starting current to full load current is 3·2, starting torque being about 35 per cent of full load torque. The stator casing diameter is 30½in, the overall length 9ft 4in and the approximate weight 7½ tons.



1000 h.p., 1475 r.p.m., double-cage, four-pole submersible motor, operating on 3000/3300V, three-phase, 50 c/s., here arranged in swinging frame to serve as a test bed dynamometer motor

Hunts Bay Power Station

IN 1950, the Jamaica Public Service Company, Ltd., placed orders for the construction of a steam power station of 40MW ultimate capacity. The original intention was to extend the existing power station at Gold Street, Kingston, but later it was decided to erect a new plant at Hunts Bay, about 1 mile to the west of Kingston. The official opening took place on October 13, 1953, with one Brush-Ljungstrom 10MW set installed; a second set is to be put into operation shortly. The plant employs unit construction, steam from an outdoor boiler being supplied to each set at 415 lb per square inch and 810 deg. Fah. The boiler is oil fired of Babcock and Wilcox integral furnace design and has an hourly capacity of 130,000 lb.

Site and Structures.—Hunts Bay power station, illustrated below, occupies a 7-acre site about 1 mile west of the centre of Kingston. Its situation on the sea-shore enables sea-water to be used for cooling, while fuel oil is supplied from the adjacent site which is occupied by the Esso Petroleum Company, Ltd.

The water level is about 4ft below the surface, with silt and vegetable earth extending to 15ft, below which are found clayey silts and sand to a depth of 60ft. The buildings are carried on reinforced concrete rafts resting on approximately 350 piles. Each 50ft pile is of reinforced concrete and can carry 45 tons. The separate rafts supporting the turbine, boiler, chimney and fans are hinged to the main raft. The buildings are of structural steel clad with reinforced concrete blocks, and roofed with corrugated metal sheeting, or in some places with concrete and filler joist flat roofs on which are sited the softened and distilled water and de-aerator storage tanks.

Rising to a height under the roof trusses of 46ft, the turbine hall has a span of 62ft and at present consists of three bays, each 17ft 6in long. The same building houses the ancillary equipment and switchgear, with the administrative section immediately adjoining. The design has been based on a wind velocity of 120 m.p.h. (50 lb per square foot).

Turbines and Alternators.—The turbine and alternator are of normal Brush-Ljungstrom design. One 5MW alternator is driven from each end of the turbine, and generates at 13,700V, 40 c/s. When the frequency standard is changed to 50 c/s the set will give a total output of 12·5MW. The alternators are fitted with integral motor fans and with closed circuit air cooling.

Initial steam conditions at the turbine are 400 lb per square inch and 800 deg. Fah. Three stages of feed heating are employed, giving a final feed temperature of 300 deg. Fah. The second stage is a combined direct contact and storage heater and de-aerator. The final stage h.p. heater is fitted between the feed pump and the boiler. In this way 2500 gallons of de-aerated feed water at approximately 240 deg. Fah. are available for peak boiler demands.

Condenser and Cooling Water.—A split design condenser enables cleaning to be carried out while the set is running. By connecting together the inlet and outlet flumes the circulating water temperature may be raised to 130 deg. Fah. in order to kill any marine growth which may have developed. Two extraction pumps, two main air ejectors, and one quick-start ejector are installed. Each of the pumps and each of the main ejectors is capable of handling the whole of the load on its own, thus providing a margin of safety and making it possible to start up quickly.

Before reaching the circulating pumps the cooling water passes through a rotary screen, where seaweed and debris are continuously being removed.

Boiler.—The outdoor boiler has a steam capacity of 130,000 lb per hour at 415 lb per square inch and 810 deg. Fah., the feed temperature being 300 deg. Fah. It is of Babcock and Wilcox integral furnace design and is oil fired by four steam jet atomising burners. The fuel heating and pumping unit includes a Weir steam pump and a Hamworthy "Y-160" electric pump, and has a capacity of 10,000 lb. per hour. The boiler consists essentially of a lower drum of 42in diameter and an upper drum of 54in diameter with rows of generating tubes connecting the two drums. In the upper drum seventeen "Cyclone" steam separators are installed. Two electrically operated rack soot blowers are fi.ted in front of the superheater. The superheater itself and the boiler passes are equipped with four and three manual multi-jet blowers respectively.

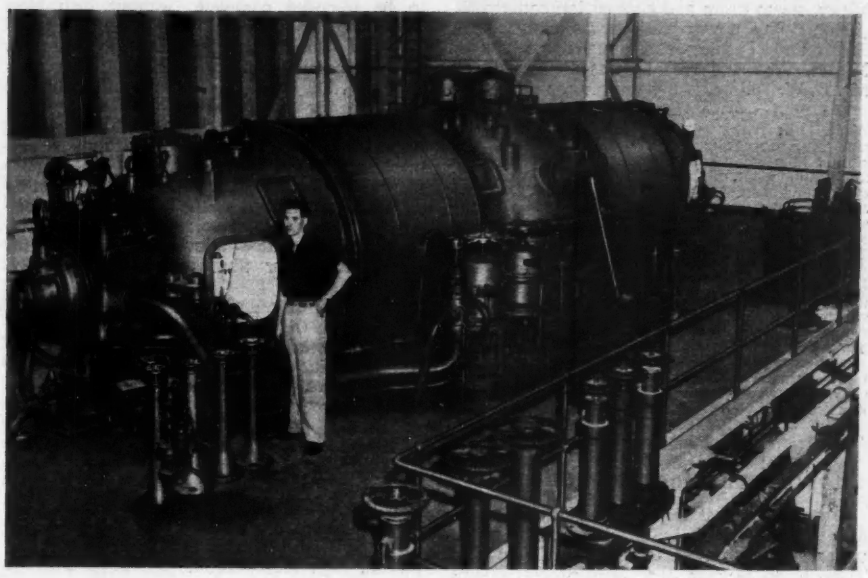
A 38,500 cubic feet per minute, 115 h.p. forced draught fan and a 75,000 cubic feet per minute, 165 h.p. induced draught fan are installed.

Water Supply and Treatment.—Make-up raw water for the softening and evaporator plants is drawn from the town mains supply. A Thompson-Kennicott base exchange softener discharges to the suction side of a pump feeding the evaporator, with a branch connection leading to a ball float controlled 6000-gallon tank on the roof. This tank provides softened water during periods when the base exchange softener is being regenerated.

The evaporator is a triple-effect 10,000 lb per hour plant and discharges into an elevated storage tank of 6000 gallons capacity, from which make-up water is withdrawn to the condenser by a level-control float valve.

After further de-aeration the mixture of condensates and make-up water is extracted by a pump and passes through the low-pressure feed heating system. It then discharges into an elevated de-aerator with integral storage tank and is finally fed to the boiler by the electric (or the steam-driven) feed pump through the high-pressure feed heater, as already described.

As the boiler unit does not incorporate an economiser, no special facilities have been provided for chemical treatment of feed water, but a chemical solution dosing bottle is connected to the boiler feed line. By this means chemicals can be added for suppressing corrosion and the



Brush-Ljungstrom turbo-alternator set generating 10MW at 40 cycles per second, or 12·5MW at 50 cycles per second

Hunts Bay power station from the south, showing outdoor boiler installation and, on left, administrative section

formation of scale and for removing the last traces of oxygen.

Auxiliary Power.—The transformers for supplying the station auxiliaries can be energised either from the station busbars or from the mains network.

Instrumentation and Controls.—The controls include alarms for high and low level in the condenser and de-aerator, and for high level in the low-pressure and high-pressure heaters. Indicating, integrating and recording meters are fitted to measure steam output and water and fuel oil consumption. Multi-point indicators for temperature and draught are installed, as well as CO_2 equipment and pressure gauges for the superheater, steam drum and combustion equipment.

Hunts Bay power station was designed by Ewbank and Partners, consulting engineers, with Messrs. Tripe and Wakeham as architects, and Mr. D. W. Tull as civil engineering consultant.

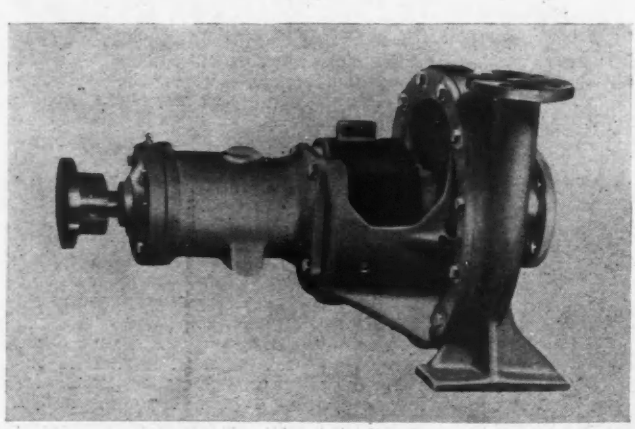
Main Plant Contractors.—Air compressors, Broom and Wade, Ltd.; boiler unit, oil fuel system, high-pressure pipework, Babcock and Wilcox, Ltd.; crane (turbine house), John Smith (Keighley), Ltd.; de-aerator plant, feed heating plant, oil fuel pumps, G. and J. Weir, Ltd.; evaporating plant, Aiton and Co., Ltd.; fans, Davidson and Co., Ltd.; instrument panel (boiler), Bailey Meters and Controls, Ltd.; instrument panel (turbine), George Kent, Ltd.; oil fuel pumps, Hamworthy Engineering Company, Ltd.; low-pressure pipework, Reginald Aitken, Ltd.; cooling water pumps, Vickers Armstrong, Ltd.; extraction pumps, Worthington-Simpson, Ltd.; feed pumps, Mather and Platt, Ltd.; high-tension switchgear, Cooke and Ferguson, Ltd.; low-tension switchgear, Electro-Mechanical Manufacturing Company, Ltd.; 30kVA transformers, Brush Export, Ltd.; 1000kVA transformers, English Electric Company, Ltd.; turbo-alternators, Brush Electrical Engineering Company, Ltd.; water softening equipment, John Thompson-Kennicott, Ltd.

Pumps for Chemicals

DURING the past eight years Hayward Tyler and Co., Ltd., of Luton, has manufactured under American licence a range of Hayward Tyler-Byron Jackson centrifugal process pumps which are interchangeable for dimensions and spare parts with the pumps made in the United States. The main application of these pumps has been for oil refinery duties and for the associated chemical and petrochemical processes involved. The pumps are suitable for working pressures of 500 lb per square inch and above and temperatures up to about 850 deg. Fah, with standard steel cases and covers tested to 750 lb per square inch or higher.

For light duties, low operating pressures and temperature conditions in chemical processes, pumps of this construction would be unduly heavy and expensive when made in high chrome/high nickel alloys or bronze.

To meet a demand for a lighter, simpler pump, for extreme corrosion resistance in the handling of chemical products, some new pumps have been developed. These new pumps have been designed to meet the requirements of the oil industry, the petrochemical industry and the chemical industry, all of which industries are now becoming more and more closely inter-related.



Pump for chemicals, made in four sizes with parts in different materials to suit liquid being handled, for delivery pressures up to 100 lb per square inch gauge and 250 deg. Fah.

The new pumps, one of which is illustrated below, are manufactured in four basic sizes in which the cover, shaft and bearing assemblies are interchangeable, and only the impeller and case vary in size. In them the stuffing-box, cover and gland drain housing are cast in one piece, so that any gland leakage can be localised, controlled and piped to drain without contaminating the base-plate or foundation. The pumps are fitted with a snap-on synthetic rubber gland cover which protects personnel from gland leakage or splashing of corrosive or dangerous liquids from the rotating shaft. The main casing cover joint behind the impeller allows the cover assembly, shaft and bearings to be removed complete, without disturbing the pump case, piping connections or base-plate. If a spacer coupling is used, the complete working parts of a pump can be removed for overhaul and replacement, without disturbing the drive or the pipework. All the pumps are arranged for the fitting of mechanical seals suitable for most chemical liquids and operating conditions envisaged. A simple means of adjustment is provided on the austenitic stainless steel shaft to set the impeller in relationship to the case with correct clearances. The open impeller fitted allows chemical slurries and "tacky" or fibrous constituents to be pumped.

The cases, covers and impellers which are in contact with the liquid handled are being made in four materials. Cast iron pumps are supplied with austenitic stainless steel shafts for handling non-corrosive liquids, concentrated sulphuric acids at low temperature, &c. Cast steel cases and covers for petroleum and petrochemical products are fitted where steel is preferred for any very inflammable liquids. Acid-resisting aluminium bronze cases, covers and impellers can be supplied for handling fatty acids and food products, where contamination is not permissible. For use where corrosive conditions prevail, high nickel-chrome austenitic stainless steel parts are made.

The pumps are suitable for delivery pressures up to 100 lb per square in gauge and for operating temperatures up to 250 deg. Fah. A full range of capacities up to 600 gallons per minute and heads up to 230ft is possible with speeds up to 2900 r.p.m.

Extensions of Truck Manufacturer's Factory

THE firm of Euclid (Great Britain), Ltd., was formed early in 1950 to manufacture in this country the earth-moving equipment made by its parent firm, the Euclid Road Machinery Corporation of Cleveland, Ohio. Whilst new offices and works were being built for the new company on the Newhouse Industrial Estate in Lanarkshire, temporary offices were opened in Glasgow and contacts were made with potential British sources of supply for parts and materials, and the necessary personnel was engaged. As a result of this preliminary work when the new premises were occupied in July, 1950, it was possible to complete the first British built machine in less than two months. At that time practically all the production materials had to be imported from the United States. As time passed and supplies of materials became increasingly available in this country the need for importing parts from America steadily decreased, and for some time now the company has been able to obtain all that it requires from home sources.

The first machines produced were Euclid 15-ton rear dump trucks and the range has now been extended to include the 12 cubic yard hydraulically operated scraper, the 13 cubic yard bottom dump truck, and more recently 22-ton rear dump trucks.

The original factory and offices covered an area of some 65,000 square feet and with the steady increase in production and widening range of machines made it became necessary to introduce an extensive factory expansion programme. An important stage in this programme was reached recently with the opening of a new building block which has increased the firm's production and office space by 96,000 square feet.

The new factory building consists of two bays 80ft wide by 600ft long, 32ft high to the roof trusses. It has been laid out as a structural shop for the fabrication of bodies, frames and other structural components, and an assembly and truck testing department. As a large amount of heavy material handling is involved in the new shops ample facilities are provided to enable the rapid and efficient transport of parts. Clear aisles 12ft wide are provided down the length of the bays to give easy access for fork lift trucks handling standard stillages. In addition to two 15-ton overhead cranes serving the full length of the building there are nine 5-ton travelling and five 2-ton jib cranes in various parts of the shops. The spans of the travelling cranes serving individual assembly areas are supported at one end on carriages running along overhead rails along the sides of the building, and at the other end on carriage-mounted towers which traverse along floor rails.

Work is arranged on a progressive production basis and starts in the structural bay at a large plate store situated at one end. The plates and sections are formed and cut on a series of presses, punching and cropping machines, and shears, and where necessary drilled either on a 6ft radial drill or a 9ft radial drill fitted on to a 40ft long traverse bed. An oxygen cutting machine in this section is fitted with four cutting heads and has magnetic tracing equipment. The size of the work handled in this section is indicated by the fact that the shearing machine installed is designed to cut 12ft long, 1in thick, mild steel and a 550-ton press brake is capable of bending 18ft long, $\frac{3}{4}$in thick, mild steel plate.

The body plates and the built-up sub-assemblies are tack welded together at the top end of the section and then transferred to large manipulators for final welding. In an adjoining section the main members of the truck and tractor frames are welded together on a series of manipulators. Each manipulator is provided with a services supply pillar extending from reels on which are the lines for compressed air and welding current cables.

A line of sub-assembly sections is arranged down the length of the side of the building opposite the structural bay. In these sections there are assembled the rear axles, front axles, engines, transmissions and hydraulic equipment.

The main assembly of the vehicles is carried out on lines down the centre of the building and the various assembly stations along the lines are fed with parts from the main stores and sub-assembly areas. For each stage of assembly a special truck, known as a stock "buggy," is supplied from the main stores with all the required components arranged on its platforms in a predetermined order to facilitate their selection by the assemblers. At the top of the assembly line the frame of the vehicle is mounted on carriages running on rails, and as assembly progresses down the line the vehicle is pushed along on these carriages until it reaches a stage where it is supported on its own wheels. Power tools are used extensively on the assembly lines and when needed hoses for compressed air and electric supply cables can be drawn from self-returning reels set in pits below floor level.

At the final assembly stage pre-set metering pumps are used to fill the completed trucks with fuel oil, engine oil, hydraulic fluid and water or anti-freeze coolant. The vehicle is then driven under its own power into the body mounting section before passing to final inspection. In the inspection area the rear wheels are supported on rolls while the vehicle is run for thirty-five minutes to provide a simulated road test. During this running time a routine final inspection is carried out and a detailed inspection sheet

completed. The trucks are then driven to the adjoining factory block for final cleaning and painting.

With the opening of the new shops and the transfer of the structural and assembly work the production areas of the original factory building have been rearranged. Where the original main assembly line was situated a final cleaning line has been laid down leading to a large paint spraying booth with water-washed walls. The machine lines are being extended and new plant installed to make possible an increase in production. A large maintenance department in this building is responsible for the servicing of all machines, cranes, trucks, &c., used in the works.

Automatic Chain Lubricator

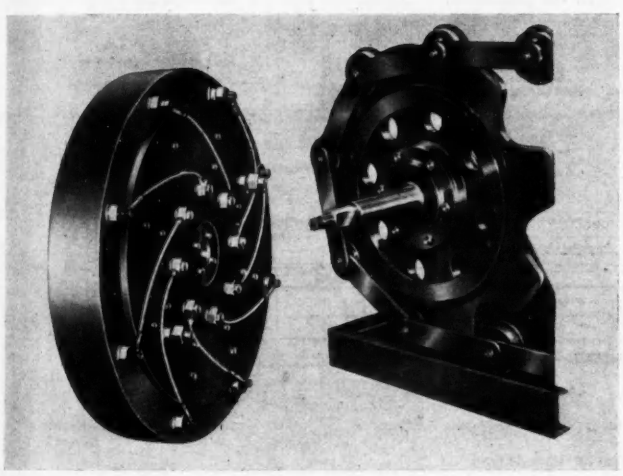
AN automatic chain lubricator now being produced by Clarke, Chapman and Co., Ltd., Victoria Works, Gateshead-on-Tyne, is designed for use with all kinds of chain conveyor and can be engaged or disengaged and assembled or dismantled as a unit while the conveyor is running. All the mechanism is totally enclosed in an aluminium case which forms an oil bath providing splash lubrication for the moving parts.

Various sizes are available to suit the pitch of the chain which is being used and the number of teeth of the sprocket wheel. With two lubricators fitted at the tail end of a conveyor, the width is not normally increased by more than 18in. Where necessary, the lubricators can be fitted at the driving end.

As shown in the illustration, the sprocket wheel rotates on bearings fitted to a stationary stub shaft. The lubricator can be slid along this shaft by a hand lever mounted on the side away from the chain, but its centre portion (inside the casing) is prevented from rotating by the square end of the shaft. The casing of the lubricator engages the sprocket wheel by means of two spigots and is then rotated by it. Equally spaced inside the casing are the injectors, each with its rocker arm and plunger. Their number depends on the size of the lubricator, and their disposition on the chain pitch and sprocket pitch circle diameter. Each plunger is spring loaded and has a self-centring nipple connector fitted to its end. At the outboard end of the device is a manifold equipped with a non-return valve for distributing the lubricant to the injectors. A short length of high-pressure flexible piping runs between each injector and its plunger, a relief valve being incorporated at the nipple connector end of each pipe. This valve is set at a higher pressure than the supply pump feed, so that the system can be filled completely.

On engaging the lubricator by means of the hand lever, each rocker arm is raised in turn and pushes forward its plunger which connects with the chain nipple which happens to be opposite to it. Lubricant is then forced into the chain link pin, and as rotation continues each rocker arm and plunger is withdrawn in turn and each injector is recharged with lubricant.

The nipple connectors are stated to be capable of accommodating themselves to a chain stretch of up to ¼in per pitch length. They can also be adjusted to compensate for wear of the sprocket wheel, while unequal height of the nipples is taken up by the spring loading. The unit is designed for working in dust or steam-laden atmospheres, but when conditions are exceptionally bad a system of air jets is fitted which automatically cleans each nipple before and after lubrication.



Tail sprocket wheel, with lubricator removed from stationary stub shaft. In operation the lubricator casing is rotated by the sprocket, and the rocker-actuated nipple connectors engage in turn with the nipples on the chain link pins

Road Vehicle Spares Store

A STORES to handle the spare parts of commercial road vehicles was opened recently by A.C.V. Sales, Ltd., at Southall. It covers an area of about 58,000 square feet and is one of the largest and best equipped buildings of its kind in the country. The site was once a 60ft deep sand and gravel pit and a steel-framed structure has been built directly over concrete piles 30/40ft deep, which are bridged together with reinforced concrete beams supporting both floor and load bearing brick structure.

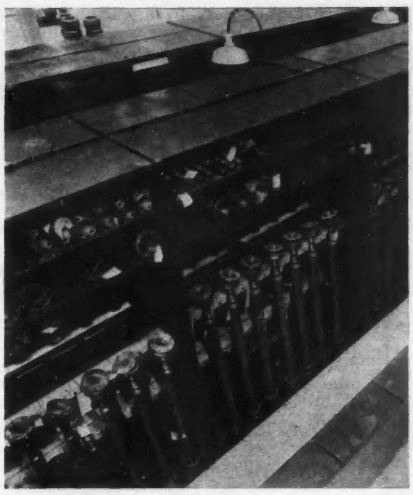
The stores was designed as a single-storey unit of some 58,000 square feet with a double-storey block on the east elevation for offices, giving a further 18,000 square feet, part of which is occupied with light storage. Two loading bays, for the receipt and dispatch of stores, are built as wings to the main building, in order to give a clear area for the stores activities within the building.

The primary aim in the design of the new building was to contain all main storage and packing on the ground floors to avoid unnecessary handling of materials. The storage area is in one main block interspersed with generous gangways between bins for mechanical transport and all receipts flow into this area and thence in one direction towards the packing and dispatching area on the west side of the building, at the end of which is the dispatch bay wing. This wing allows two of the largest vehicles to be driven in and loaded simultaneously.

In the receipts bay is located the packing-case manufacturing and storage area which is equipped with two woodworking machines, electrically heated and thermostatically controlled dipping tanks for complete cleaning and preserving treatment and a spraying plant and spray booth for treating complete engines and units which cannot be immersed. Three battery-charging boards for the electrically powered stores transport are also located in this area.

The main storage binning, which was specially constructed to the company's design and specification, was supplied and erected by Steel Equipment Company Ltd., of West Bromwich. It was built to a standard height of 10ft 3in, the maximum height at which stores can conveniently be handled from one floor. All bin sections have been designed to be of sufficient strength to support additional bins above, mounted directly upon extruded metal flooring, with a further bin height of 6ft to take care of future expansion and also to utilise the full height (18ft to the underside of the roof trusses), which would otherwise be wasted space.

The binning is mainly of the adjustable pattern, shelves being adjustable at 2in steps. Vertical dividers are also adjustable. Amongst new developments are special racks, as illustrated, for specialised storage, i.e. valves, cardan shafts, spring leaves, road springs, exhaust pipes, differential and gearbox assemblies.



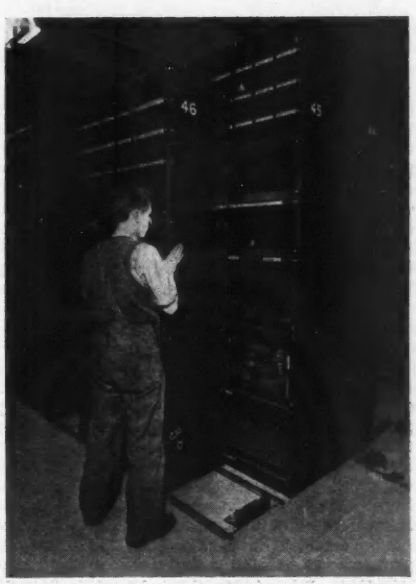
A typical section of adjustable racking, showing adjustable cardan shaft rack with allied component stored above

Incorporated in the structure of the building is a gallery running two-thirds its length at a height of 10ft 6in along the inner wall of the office block, with access from the central staircase, the main purpose being to provide staircase access to future second floor storage without structural alteration. A central staircase incorporates a self-operated 2-ton passenger and goods lift.

The light storage area is used for lightweight spares and valuable parts and may be entirely shut off from the main stores and offices if required at any time. It is partly equipped with mobile sliding bin units, as illustrated below, and is designed to make full use of all available floor space in view of the restricted ceiling height available on this floor.

Lighting in the first floor store and in the ground floor storage area immediately below this is supplied by special dispersive tungsten bin light fittings designed for maximum lighting between narrow rows of bins. The main single-storey stores area has both high-level tungsten lighting for general purposes, and low-level light fittings between rows of bins.

The handling of heavy stores and packing-cases in the building is done by an extensive system of Kings electric span cranes and monorails.



Mobile bin units giving increased storage capacity on same floor area, for items in frequent use

Materials Testing Reactor of the U.S. Atomic Energy Commission

(By Our American Editor)

No. I

The Materials Testing Reactor (MTR) of the U.S. Atomic Energy Commission has been in operation at its full rated power of 30MW since May, 1952. The pile was designed and constructed by the A.E.C. primarily to provide facilities for testing materials in radiation fields of very high intensity. The MTR is a thermal neutron reactor using enriched uranium as fuel, ordinary water as both moderator and coolant and beryllium as reflector. It produces average neutron fluxes of 2×10^{14} thermal neutrons per square centimetre per second and 1×10^{14} fast neutrons per square centimetre per second, and is said to have the highest thermal neutron flux of any pile now in existence

THE Materials Testing Reactor (MTR) of the U.S. Atomic Energy Commission, which is in operation at the National Reactor Testing Station in Idaho, is a high-flux heterogeneous enriched-fuel reactor. The active part of the reactor consists of enriched U^{235} fuel elements arranged to allow water to flow between them, the water thus serving as both coolant and moderator. Immediately surrounding the small enriched lattice is a primary reflector of beryllium metal, which is also water-cooled. This whole assembly of active lattice and beryllium reflector is mounted in a tank system through which the water flows and which contains the control rods and their bearings. Outside the tank system are a secondary reflector of graphite, a thermal shield, and a biological shield, the whole forming an approximate cube of 34ft sides. As its name implies, the reactor has been designed primarily to allow the testing of various materials in fields of high-intensity radiation. To accomplish this purpose about one hundred experimental holes have been provided, going, respectively, through each of the four walls, the top, and the bottom of the reactor. This article is based on information on the design of the MTR which has now been released by the U.S. Atomic Energy Commission.

Applications of the MTR

The need for a materials testing reactor is due to current reactor technology entering the fields of higher fluxes, which in turn has led to many problems requiring experimental answers. For example, the effect of high fluxes, particularly of fast neutrons, on the properties of structural engineering materials is still not well known. Some structural materials, such as graphite, are known to suffer ill-effects in a relatively short time. Metals which have desirable structural properties as a result of cold working or of heat-treatment may conceivably undergo adverse changes under fast neutron bombardment. Furthermore, the cross-section of the fission products may determine to a large extent the breeding gain or the operating time of a power reactor. Apart from these urgent and immediately practical problems, there are many fundamental experimental studies in high-flux regions which can be carried out in the MTR. The high density of epithermal neutrons in the MTR permits the extension of the practical range of the crystal spectrometer to higher neutron energies. The properties of fissionable isotopes in the lower resonance energy regions may thus be investigated and their nuclear constants more accurately determined. Again, reactions of higher order (the capture of two or more neutrons in succession by the same nucleus) can be made to produce significant quantities of rare isotopes, thus permitting the study of their nuclear constants.

Another use of the MTR is in the production of radioactive isotopes in amounts and of specific activities which previously had not been readily available. For example, the MTR can produce phosphorous compounds of higher specific activity which are usable directly, without purification or chemical separation, by clinical institutions, and it can produce very strong Co^{60} sources. The extent to which the criterion of higher flux is satisfied by this pile is shown by the following comparison of the MTR with other American reactors now in operation:

Reactor	Heat output	Average thermal neutron flux
Oak Ridge graphite reactor ...	3,000kW	1×10^{13} n/cm²/sec
Brookhaven graphite reactor ...	25,000kW	5×10^{13} n/cm²/sec
Argonne heavy-water reactor	300kW	4×10^{13} n/cm²/sec
Canadian heavy-water reactor	10,000kW	5×10^{13} n/cm²/sec
Materials testing reactor ...	30,000kW	2×10^{14} n/cm²/sec

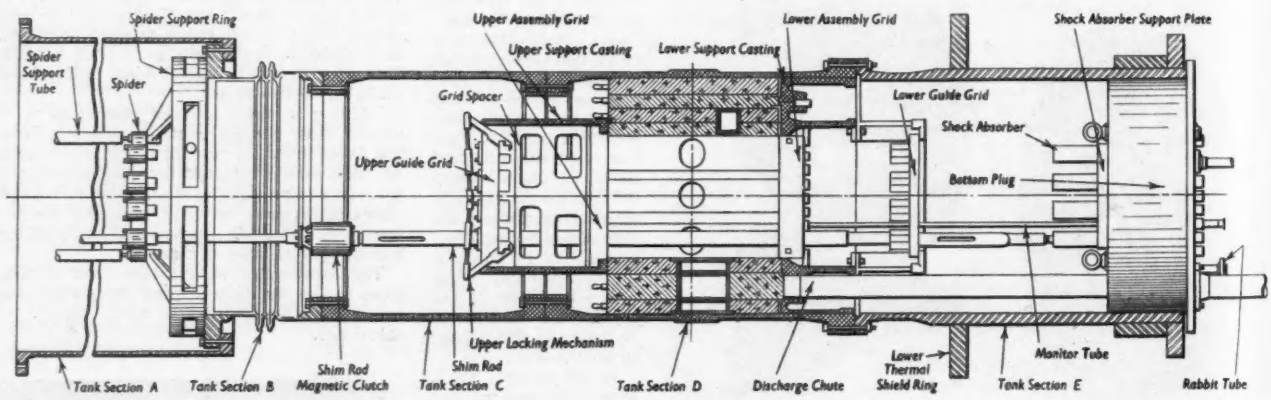
The MTR provides thermal and fast neutron flux levels for component testing and materials irradiation which are high enough to be used in the design of future reactors now under consideration. It also provides several experimental holes designed to permit the irradiation of reactor components, such as fuel assemblies, under simulated operating conditions of temperature, pressure and particular coolant. To produce these high neutron and heat fluxes, however, means a sacrifice in volume for experimental facilities and causes a high fuel burn-up and certain operational difficulties.

History of the MTR

Late in 1944 the Chemistry Division at the Clinton Laboratories (now the Oak Ridge National Laboratory) proposed the construction of a 50kW homogeneous uranium heavy-water reactor, whose main purpose would be to produce easily extractable fission products. Work on such a 50kW homogeneous reactor continued until 1945, when it was decided that the power of the reactor should be raised sufficiently to demonstrate the feasibility of a thermal energy breeder. Additional problems then arose which led to difficulties in the conception of the control and technology of a homogeneous reactor. Principally, there was the instability of a homogeneous reactor that contains bubbles of gas arising from the disintegration of solvent molecules and the generation of fission products. Although the reduction of power to a 50kW level would have eliminated the problem of bubbling instability, this would have defeated the purposes of such an enriched reactor. Accordingly the alternative was to go ahead with another reactor which would produce similar flux conditions and to use it to study the problems of the homogeneous reactor by small-scale experiments at high flux.

A heavy-water moderated and heavy-water cooled enriched heterogeneous reactor was first designed. Later, the technical division of the Clinton Laboratories submitted a design proposal in May, 1946, for a high-flux thermal reactor of heterogeneous core which was to be light-water cooled and heavy-water moderated and reflected. The use of light water as a coolant was believed preferable to the use of heavy water because light water increased the operational flexibility of the machine. A critical examination of this design showed that an important gain in fast flux could be obtained by using light water for both coolant and moderator. This change would result in a smaller reactor and, because fast flux is proportional to power per unit volume, it was established that a 30MW reactor of the proposed design could produce a fast flux of approximately 1×10^{14} neutrons per square centimetre per second.

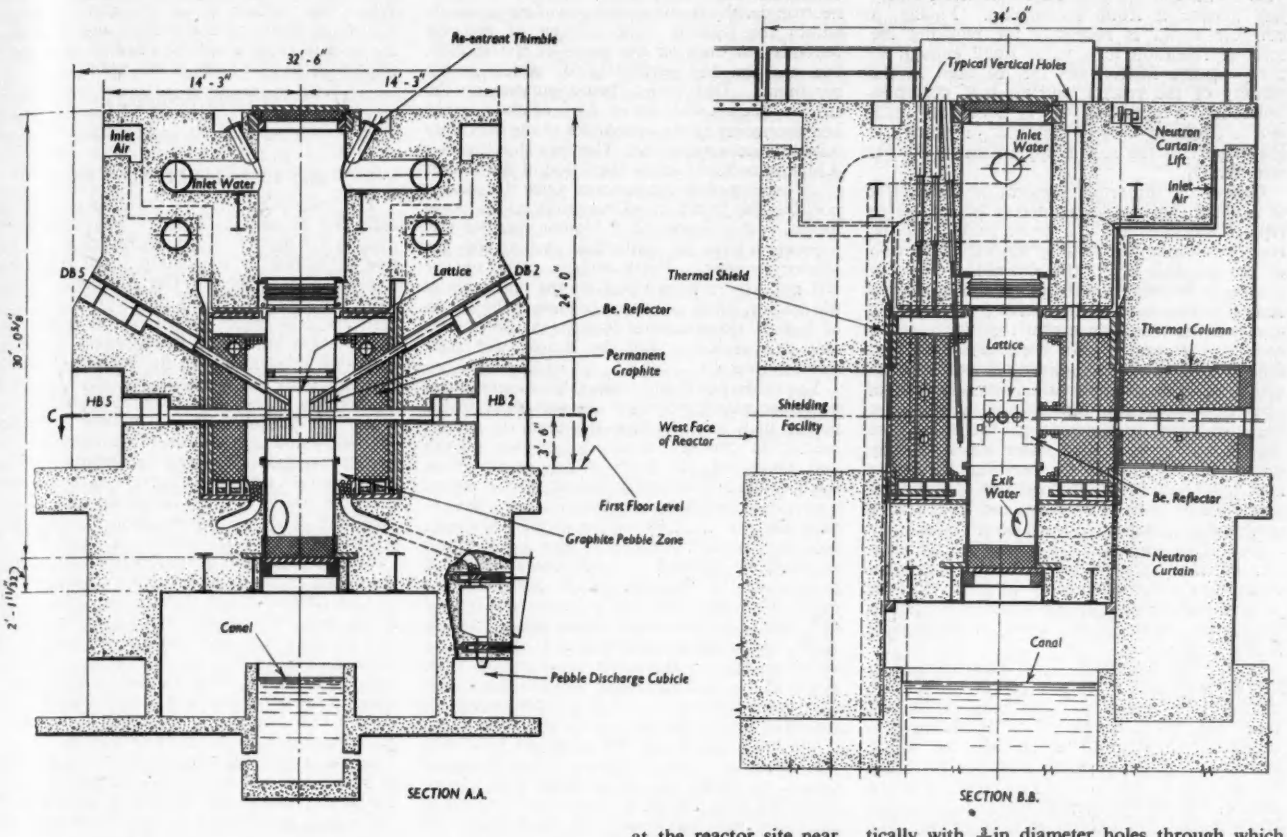
In the previous design with heavy-water moderation and reflection, the reflector merely provided space for experiments that could be accomplished otherwise. In August, 1946, it was therefore decided to eliminate heavy water altogether and to make the reflector of beryllium. The decision with respect to beryllium was made possible by the rapidly improving situation in the United States in 1946 in the metallurgical techniques of handling and fabricating this metal on a production basis of tons rather than pounds. Thus, by the summer of 1946, the design for the experimental high-flux reactor had evolved from an initially homogeneous fluid

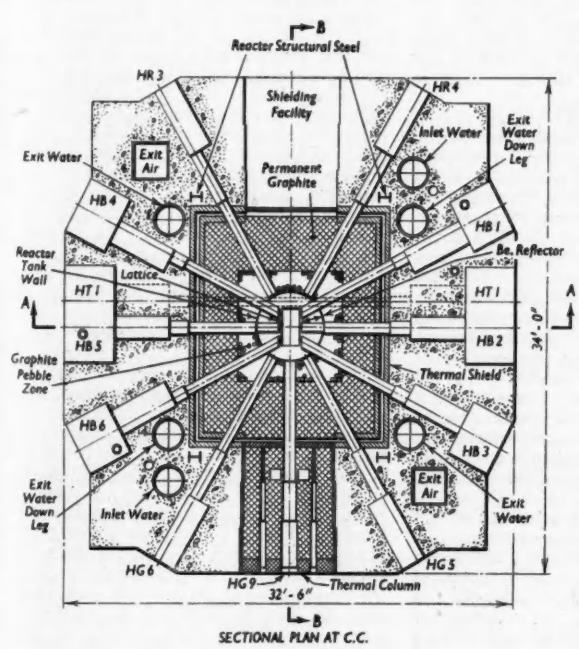


General arrangement of reactor tank system

reactor to an all-metallic rigid machine, apart from the cooling fluid, which was to be ordinary water.

Once the basic design principles had been established, a scale model of the MTR was built at the Oak Ridge National Laboratory, and in January, 1950, this model of the MTR was brought to criticality. During the spring, summer and early autumn of 1950 this model reactor was operated hundreds of times at power levels of a few hundred watts, and many measurements of vital importance to the MTR were made. As an example, it was on the basis of these measurements that the final design details of the graphite reflector and the thermal shield were evolved and the overall design of these items was finally approved. In February, 1950, the Fluor Corporation, of Los Angeles, was engaged by the Idaho Operations Office of the Atomic Energy Commission as construction contractor for the MTR. Ground was broken at the reactor site near Idaho Falls, Idaho, in May, 1950, and construction was completed in February, 1952. In July, 1951, the Phillips Petroleum Company was appointed as the operating contractor by the A.E.C. The MTR became critical on March 31, 1952, and underwent further tests preparatory to final acceptance by the operating contractor. On August 2, 1952, the first experimental tests were inserted in the reactor.





Vertical cross sections and horizontal cross section of reactor

Reactor Layout

The reactor consists of U^{235} as the fissionable material, ordinary water as the moderator and coolant, and beryllium as the reflector. The active core in which the uranium is situated can be placed as desired within a "lattice" which is 40cm by 70cm in cross section. Each fuel element fits into a socket underneath the reactor, and a grid fits over the tops of the elements in order to preserve their spacing at the top. Beryllium is situated immediately around the elements. The beryllium continues to the inner wall of a 1in thick cylindrical aluminium tank which has an inside diameter of 4ft 6½in and in which the active portion of the reactor and beryllium is situated. This tank extends both above and below the active portion of the reactor, forming a well which is, and must be, kept full of water at all times. Water enters near the top of the well at a distance of about 15ft above the reactor and leaves at the sides of the well about 5ft below the reactor. The beryllium around the active portion of the reactor is perforated vertically with $\frac{3}{16}$in diameter holes through which water passes to remove the heat generated in the beryllium. In these beryllium assemblies other materials can be inserted to make use of the leakage neutrons.

Part of the purpose of the MTR is to provide as large a neutron flux as possible over as great a volume as possible. To accomplish this, a secondary reflector of graphite is placed outside the reactor tank. The main problem in the design of the graphite reflector was the possibility of graphite dimensional changes due to radiation, oxidation and temperature rise. To overcome this difficulty, the graphite reflector was divided into two zones ; a pebble zone that is adjacent to the reactor tank and extends for a minimum of 40cm from the tank wall to form a square, and a permanent graphite zone that is 12ft overall north to south, 14ft overall east to west, and 9ft 4in high.

The pebble zone is a volume 7ft 4in square by 9ft high. It surrounds the reactor tank and is filled by some 700,000 graphite pebbles 1in in diameter. The pebbles rest on a base plate mounted on the lower thermal shield plate and are free to expand upward. In this way any expansion will merely raise the level of the balls without exerting undue stress on the tank wall or the permanent graphite. Two discharge chutes in the pebble-support plate can be opened into a discharge bin, thus allowing the removal of the pebbles at any time. Since the pebbles are in the highest flux region of the graphite reflector, any radiation damage will affect them first, and when necessary, they can be replaced.

The permanent graphite is composed largely of 4in by 4in graphite bars stacked to a height of 9ft 4in with the bottom situated 4ft below the centre line of the active section. This graphite structure is penetrated vertically by numerous holes which serve both to permit the passage of air for cooling the graphite and to permit the insertion of materials to be bombarded. In addition, the sides are penetrated by a number of

holes designed especially for experimental uses. Outside the graphite are two 4in thick layers of steel, also air-cooled, which absorb most of the neutrons leaking out of the graphite and in which most of the residual energy of the radiation from the reactor is given up. The approximate size is 16ft in the north-south direction, 14ft in the east-west direction, and 12ft 6in high. This thermal shield protects the concrete shield just outside it from overheating. Finally, a concrete shield is necessary for reducing the level of radiation to a value small enough so that sensitive instruments can be used in the vicinity of the reactor and so that personnel protection is provided. It is about 9ft thick and is made of barytes concrete, in which the gravel part of the mix is approximately 93 per cent $BaSO_4$.

One of the important features of the reactor is the fact that its design makes it possible to replace the tank and the active portion of the reactor without dismantling the major portion of the graphite or of the shielding. This, of course, is a major undertaking and consumes several weeks, even with careful planning. To this end the materials within the highly active zone in the reactor have been chosen in part for their lack of long-lived induced radioactivities. For example, aluminium is used in place of stainless steel in this zone. An attempt has also been made to design the reactor so that it can be dismantled under water piece by piece. For this reason the beryllium pieces are kept small, and for this reason also the proposal that the tank with all its contained beryllium be removed as a unit was turned down. This high degree of flexibility makes it possible to insert another kind of reactor of identical external dimensions in the hole left by the removal of the present reactor tank. It also makes it possible to replace the reactor in the event of damage or failure in operation.

In normal operation, each fuel element is left in the reactor until a certain percentage of the U^{235} contained has been consumed. When this point is reached, it is desirable to withdraw the elements to remove the fission products from the uranium and then to return the uranium in the form of new elements to the reactor. The physical removal and recharging of the reactor are accomplished using grappling devices by means of which an element can be lifted out of its socket and moved across the top of the lattice to a position directly over a hole through the beryllium beneath which is a water-filled discharge tube leading to an unloading machine in a deep canal immediately under the reactor. The hole through the beryllium is plugged with a beryllium plug during operation. At the time of unloading, this plug is removed. The discharge tube that leads to the canal connects with a receiving tube through a valve and seal which act as locks to prevent excessive loss of water from the reactor. This receiver can be rotated hydraulically to a horizontal position to discharge the fuel element in a horizontal position under 10ft to 15ft of water in the canal. New elements are loaded into the spaces left by the old ones by lowering them through the water from the top of the well.

Reactor Design

The heat output at which the reactor is designed to operate is 30MW. This value was determined primarily by the heat-transfer coefficients attainable in the active portion of the reactor and by the permissible surface temperature. In order to make it possible to operate at higher power if the above conditions turn out to have been too conservative, the cooling of the graphite, the shields, and the thickness of the shields have been designed for a 60MW output with some safety margin. The external water system has been designed for only 30MW, but additional cooling capacity can be added later.

Two points concerning the physics of the reactor are of particular interest. The first is the fact that the maximum slow-neutron flux exists not in the active portion of the reactor itself, but in the adjacent reflector. The reason for this is that the cross section of the reflector per unit volume for absorption of slow neutrons is less than that of the reactor; therefore, neutrons which become slow in the reflector live longer than those which become slow in the reactor itself. This leads to a building up of neutron density in the reactor adjacent to the reflector. The extent of the rise of the slow-neutron flux outside the active section of the reactor depends on the shape of the reactor. It is greatest for a slab loading and least for a cylindrical loading. Under the most favourable conditions the extent of the rise of the slow-neutron density is about that prevailing generally within the reactor. The amount of the rise depends not only on the shape of the reactor, but also on the percentage of water in the beryllium. This varies, being greatest at the surface nearest the active part of the reactor and decreasing as the extremities of the beryllium reflector are approached. The fact that the flux is highest outside the active portion of the reactor is an experimental convenience since this makes possible the insertion of materials to be bombarded into the region of highest thermal flux without interfering with the cooling of the reactor proper. Furthermore, such objects will not have a large effect on the reactivity of the reactor, since, although they are in the region of highest slow-neutron density, in the present case this region is not the region of highest statistical weight.

The other point of considerable interest from a nuclear physics aspect is the fact that, owing to the high neutron flux, the reactivity of the reactor is strongly dependent on the growth and decay of the Xe^{135} which results from the decay of I^{135} formed in fission. Under steady operating conditions at 30MW, the loss of reactivity due to Xe^{135} will be about 4 per cent. However, when the reactor is shut down after a relatively long period of steady operation at full power, the I^{135} which is already present as the result of fission and which has a half-life of 6·6 hours, continues to decay, giving rise to Xe^{135}, which has a half-life of 9·4 hours, and a very high neutron absorption cross section. The result of this is that within the first hour after shut down the reactor will lose 9 per cent of its reactivity and within two hours after shut down it will have lost 16 per cent of excess reactivity. The maximum loss of reactivity due to xenon occurs at about ten hours after shut down. After this time, the xenon content of the reactor decreases, with the result that after forty-eight hours the reactivity is only a few per cent less than during steady operation at 30MW prior to shut down. After sixty-three hours, the reactivity is again equal to that prevailing at shut down.

The significance of this state of affairs is that, if the reactor is accidentally shut down during steady operation at high power and not restarted promptly, it requires a large amount of excess reactivity to get it going again. Once started, the accumulated Xe^{135} will be rapidly consumed by the operation of the reactor itself, and the reactivity of the reactor then increases, approaching its normal steady running value. It is not considered safe to build into the reactor enough excess reactivity to take care of the maximum amount of xenon "poisoning" that might occur. This imposes on the operator the necessity of getting the reactor going quickly after an accidental shut down. If he does not get it going quickly enough, he will not be able to start it for about two days. In consequence, the control system has been designed to permit starting the reactor rather rapidly. Another and obvious consequence is that it will not be permissible to shut down the reactor at frequent intervals in order to accommodate experimental workers, unless the experiments in question are of considerable importance, since to do so is likely to put the reactor out of operation for two days. Accidental "scrams" of the reactor are also to be avoided unless there is some bona fide reason for them; for this reason the control system of the reactor provides automatic setback to a relatively low power level from which it is easy to come quickly to full power again if the reason for the alarm turns out to have been false or unimportant.

The general arrangement of the shielding of the reactor is illustrated in the drawings we reproduce. The concrete shield is 9ft thick, which is conservatively ample to reduce the intensity of radiations of all kinds at the surface of the shield to one-tenth or less of the standard eight-hour tolerance. This is desirable in order to provide a low instrument background in the region around the reactor. The shielding above the reactor during loading or unloading is just the column of cooling water. Its height of 20ft. above the centre line is such that the radiation level at its surface when the reactor is shut down is below 0·1 röntgen per eight-hour period. When the reactor is in operation, however, additional shielding is necessary and is supplied by the top plug, which is made of steel and is filled with an 11in layer of lead shot.

(To be continued)

Hot Extrusion of Alloy Steels

The increasing success obtained in the hot extrusion of steel in America has now put the process in a much stronger position as an alternative to rolling or machining small production lots of special shapes. The Allegheny Ludlum Steel Corporation reports the extrusion of tough stainless steel grades for jet engine rings as one of the most important achievements of the hot extrusion department at its Watervliet Works. The company has recently produced a variety of complex shapes for aircraft use that demonstrate the flexibility of the process in forming high-alloy and high-temperature materials. From a cost standpoint, the two factors that indicate the use of hot extrusion are: (1) a volume which does not justify the cost of special rolls, and (2) small lots of complex shapes made from expensive high-alloy steels. In the case of small lots, the extrusion process offers substantial advantages. American rolling mills generally are not anxious to take orders for less than 10 tons of a rollable shape, and the customer is charged for lost production time for roll changes as well as the expense of cutting special rolls, which can amount to thousands of dollars. Hot extrusion dies, on the other hand, cost relatively little, and there is little production loss involved in changing from one shape to another on the press.

In the case of high-alloy special steels, extrusion in many cases may be less expensive than machining in very small lots. When the fabricator cuts away large percentages of special steels, as must be done in many aircraft components, the net cost per pound of the part increases greatly and the inherent advantages of hot extrusion become apparent. Extrusion can reduce machining time on some parts, and in certain applications can eliminate set-up and machining altogether by subsequent cold drawing. The slow machining speeds necessary on many high-alloy materials also add to the advantages of the hot extrusion process. The comparatively short production time required for extrusion dies and the low costs involved make the method ideal for production of prototype and experimental aircraft. Small tonnages can be produced for original test models, and the dies are readily available for production quantities at a later time if they are needed. The company is at present producing a number of different parts for jet engine and non-military use. Several different shapes have been extruded for rings, and one extrusion is being used for chain links in place of forged links. The extruded shape is cut into sections and drilled at each end to form links. A non-military part in the pilot production stage is a receiving cylinder for soldering tin cans. Two extruded pieces of stainless steel are joined to make a cylinder which was previously made of carbon steel and had to be machined, polished and plated. Only finish machining of the stainless steel extrusion is now necessary, and the part is expected to have a much longer life.

The grain structures of as-rolled and as-extruded sections compare favourably, according to the firm, and no major problems with segregation are reported. At present the company is extruding various grades of stainless and tool steels, using the Ugine-Séjournet glass lubrication process. Small quantities of "super-alloys" and titanium alloys have also been extruded on the present equipment, and the company expects to increase its work with those materials in the future.

Industrial and Labour Notes

Overseas Trade

The Board of Trade has issued some provisional figures relating to the United Kingdom's export and import trade in October. It states, however, that these figures do not give any useful indication of the trend of the country's trade because of the recent dock strike, and that it will probably be another two or three months before the figures reflect settled conditions again. Furthermore, because of the intervals between dates of arrival or shipment and dates of recording in the trade returns, the October figures cover only a part of the period affected by the strike.

The total recorded value of exports in October was £214,900,000, which was higher than in August and September, but 6 per cent less than in October, 1953 ; the value of exports in August and September was 4 per cent higher than in the comparable months of last year. Normally, of course, the month of October shows a seasonal increase in exports over August and September, which months are affected by holidays. The recorded value of re-exports in October was £9,000,000. The value of imports so far recorded in October was £228,200,000, which represented a decrease of 20 per cent compared with September.

Industrial Health Services

On Thursday of last week, the Minister of Labour, Sir Walter Monckton, Q.C., made an announcement in the House of Commons about plans for stimulating the development of industrial health services in workplaces covered by the Factories Acts. These plans include the appointment of a standing industrial health advisory committee to advise the Minister ; a review to find out where industrial health services are most urgently needed, and the promotion of surveys and field investigations where further information is required to determine the need for preventive measures or research.

In his statement, the Minister welcomed the work already done in industry, both voluntarily and under the Factories Acts, and said that he felt sure that the further development of industrial health services could make a material contribution to the country's social and economic progress. The general aim, the Minister stated, would be to develop industrial health services on a voluntary basis. He added, however, that he would also consider, in appropriate cases, and after full consultation with the parties concerned, making use of his statutory powers under the Factories Acts. The industrial health advisory committee, the Minister explained, would consist of members nominated by the British Employers' Confederation, the Trades Union Congress, the nationalised industries, the British Medical Association, the Association of Industrial Medical Officers and Certifying Factory Surgeons, the Royal College of Nursing, the British Occupational Hygiene Society, and the universities, with representatives of interested Government departments in attendance.

The Ministry of Labour has stated that the advice of the committee will be sought on such matters as the encouragement of firms to develop industrial health services on a voluntary basis. This would involve making greater use of the advice of factory doctors appointed by the Minister under the Factories Acts, employing industrial medical officers, nurses and first-aid workers, and participating in group industrial health schemes. It would also include making greater use of the services of engineers, chemists and other scientists on health problems in industry. The scheme in general will be carried out through H.M. Inspectorate of Factories.

Recruitment to the Factory Inspectorate

On the motion for the adjournment of the House of Commons last Friday, there was a debate on the subject of recruitment to the factory inspectorate. The matter was raised by Dr. Barnet Stross, who said that he was anxious to draw attention to the serious shortage of new entrants with suitable professional qualifications and technical experience.

In replying to various points raised during the debate, the Parliamentary Secretary to the Ministry of Labour, Mr. Harold Watkinson, said that the normal wastage in the factory inspectorate was fifteen to twenty a year and the normal intake was about a dozen successful candidates from open competitions twice a year. On grounds of figures alone, there was no great difficulty in keeping the cadre up to its full strength now. The difficulty was not so much recruitment as the technical ability and qualifications of those recruited. On the whole, the factory department would like 50 per cent of its members to be technically qualified, but the present figure was 36 per cent. At present, Mr. Watkinson continued, there was a terrific shortage of people with scientific and technical qualifications in British industry as a whole, quite apart from the Ministry of Labour's factory department and other Government departments. The main competition came from industry, although the Ministry faced a much more difficult situation. The factory department was being examined, Mr. Watkinson added, to determine whether some reorganisation of duties and some balancing-out of the technically trained people might be useful in the future. But it had to be accepted that even pay conditions might not necessarily redress the balance.

Mr. Watkinson went on to say that we were on the threshold of a new industrial era, and that the factory inspectorate would have changed responsibilities and changed duties with which to cope. There was, for example, the industrial use of atomic power, and, of course, the industrial use of radioactive substances, which meant a new technique of inspection, prevention and control. Yet another example was the increasing use of electronic control of industrial processes. Furthermore, Mr. Watkinson observed, there had been a lot of talk lately about automatic factories. Automatic factories would still need factory inspection because of the great risks of a disastrous runaway if the automatic control system broke down through not being properly looked after. For those who were looking on the factory inspectorate as a career, it was going to be a much more interesting and stimulating career in the future than it had ever been in the past, notwithstanding the very great past of the service in the last 120 years.

Industry's Needs

In a chairman's statement, which has been circulated in connection with the forthcoming annual meeting of Tube Investments, Ltd., Sir Ivan Stedeford comments that industry to-day is placing greater emphasis than ever before on better education and technical training. He points out that the demand for scientists and technicians of almost every grade already greatly exceeds the supply at a time when requirements are rapidly mounting. This, Sir Ivan says, is a problem of national importance, the impact of which is already hindering industrial progress.

One of the factors contributing to this situation, the statement continues, may be the dearth of teachers of science and mathematics in the schools. A recent survey estimated that there might be a deficiency of 2300 in these subjects by 1960. At the same time, Sir Ivan observes, the tendency persists among teachers and parents to channel the brighter children towards what have commonly been called the " white collar " vocations. He suggests, therefore, that a fundamental change in our thinking about careers is overdue. The variety of office jobs may have served the young people of past generations well enough, but it must be questioned whether adequate opportunities are likely to be found among them for the coming generation. Mechanisation is rapidly spreading throughout the offices of industry and commerce, and with the greater application of electronic devices the process will accelerate. This, Sir Ivan asserts, envisages a dwindling office population in the years to come.

Sir Ivan goes on to say in his statement that our traditional ways of thinking and doing are likely to be challenged in other ways by this technical new age. Electronic and other complicated labour-saving machines and equipment will be increasingly employed in factories, and the premium they will place on technical qualifications and skill must in the long run have a fundamental effect on the present methods of assessing wage rates. If, Sir Ivan says, we are to develop the greater resources of personal skill which a prosperous industry will demand, the inevitable marked differences in men's qualifications will call for a greater differentiation in wages than now exists. There has been a tendency in recent years, the statement adds, to narrow the gap between the pay of the skilled and the unskilled, thereby discounting technical ability. Such a wage policy, Sir Ivan asserts, if continued in face of these potential technical developments, must surely be unrealistic.

Iron and Steel Production

The Iron and Steel Board has stated that, during October, British steel production was at an annual rate of 19,472,000 tons, the output of ingots and castings averaging 374,500 tons a week. In October, 1953, steel production was at an annual rate of 18,460,000 tons. Pig iron output in October this year averaged 230,700 tons a week and was thus at an annual rate of 11,998,000 tons, compared with an annual rate of 11,519,000 tons in October last year. The Iron and Steel Board says that over the first ten months of this year, steel production was at an annual rate of 18,428,000 tons and pig iron production was at an annual rate of 11,045,000 tons.

Nickel Supplies

Last Monday, the President of the Board of Trade was asked whether he would make a statement about the current shortage of nickel supplies and about any action which was being taken to overcome it. A written reply by the Minister of State, Board of Trade, Mr. A. R. Low, says that supplies of nickel are slightly better than in 1953, but that the demand in this and other countries has increased still further. The Minister says he understands that steps are being taken to expand the output of nickel, though this cannot be expected to provide a solution in the short term. While the Government has no responsibility for the purchase or the distribution of nickel, the Minister of Supply and the President of the Board of Trade are considering whether any further action can be taken to help in the present difficulties.

Anglo-German Co-operation

In an address to the Dudley Chamber of Commerce last Tuesday, Mr. T. H. Summerson, vice-president of the Association of British Chambers of Commerce, referred to a visit of British business men to Western Germany earlier this year, to discuss future Anglo-German co-operation in industry and commerce. Mr. Summerson said that this delegation, of which he was the leader, heard enough to form the opinion that many of the problems to be faced in British business were similar to those which confronted German business men.

Mr. Summerson referred in particular to alleged unfair competition abroad. There had been much talk in the past, he said, and much suspicion about our Continental competitors' business methods. There had been rumours of export subsidies, of unfair trade practices of various kinds, of under-cutting due to alleged lower wage-rates, longer hours, non-existent safety precautions and bad working conditions. The British delegation had discussed these topics with their German counterparts who, he said, were able to disabuse them of many of their suspicions. It was very clearly appreciated, Mr. Summerson observed, that unfair competition inevitably brought retaliation in its train. Mr. Summerson thought that, in any case, it seemed clear that getting together with these formidable competitors would increase the prospects of competition between the two countries becoming regulated in accordance with fair practice on both sides.

Notes and Memoranda

Rail and Road

LOCOMOTIVE MEN'S WAGES.—The Railway Staff National Tribunal has made a recommendation that the wages of the locomotive staff of British Railways should be increased by 2s. 6d. a week for a first-year engine cleaner to 14s. a week for a top-rate driver. This follows the recent hearing by the Tribunal of a wage claim originally put forward by the Associated Society of Locomotive Engineers and Firemen and rejected by the British Transport Commission. The award covers some locomotive men, however, who belong to the National Union of Railwaymen. Both unions will now decide whether to accept the Tribunal's findings, which are not legally binding, and there will then be further discussion with the British Transport Commission. It is recommended that the increases should be backdated to October 4th.

PRESTRESSED CONCRETE MAIN LINE BRIDGE.—Steel is generally the main constructional material used by the railway engineer for main line bridge construction, but in the recent widening of the Nottingham-Mansfield line near Radford (Nottingham) on British Railways (London Midland Region), a bridge to carry a single line over the River Leen was needed quickly, and was built of prestressed concrete, principally because of the uncertainty of steel plate deliveries. The bridge is of 60ft skew span with main girders at 12ft centres and a floor 10in thick spanning between them at the bottom flange level. The main girders are of I section, 6ft deep overall, with 2ft 3in wide flanges and a 9in thick web. Prestressing of each of these girders was accomplished by three Magnel-Blaton cables, two of which, in the bottom flange, are straight, and are each composed of forty wires, 0·276in diameter, while the third cable is curved and comprises thirty-two wires, also of 0·276in diameter. The floor is thickened at each end to form a skew end beam spanning between the main girders at the bearings and prestressed by Freyssinet cables, each composed of twelve wires of 0·20in diameter. The whole span was concreted in-situ, using ready-mixed concrete of a specified twenty-eight-day strength of 7000 lb per square inch and with the addition of 1 per cent of a plasticiser to assist in obtaining a compact concrete, particularly around the cables at each end of the bridge, where, owing to the skew, the cable arrangement was rather complicated. Internal vibrators were used throughout the work. Concreting proceeded in three stages, namely, half the length of the floor and bottom flanges of main girders ; the remaining half of floor ; and the webs and top flanges of the main girders. Both steel and timber forms were used, supported on a falsework of steel beams erected on the new abutments at each end and on temporary piles driven into the river bed at mid-span. The two new abutments are of mass concrete faced with brickwork, and were constructed inside cofferdams of steel sheet piling. Rocker bearings of "Meehanite" cast iron are provided at each main girder bearing, set in position before the falsework for the support of the superstructure concrete was erected. The site work was carried out by direct labour to the design of the regional headquarters bridge office under the direction of Mr. J. Taylor Thompson, M.C., M.I.C.E., civil engineer, British Railways, London Midland Region.

Air and Water

SHIPBUILDING EMPLOYERS' FEDERATION.—At the annual general meeting of the Central Board of the Shipbuilding Employers' Federation, which was held in Edinburgh on November 12th, Mr. Charles A. Winn was elected president for the coming year. Mr. Winn is joint managing director of C. H. Bailey, Ltd., director of the Bristol Channel Ship Repairers' Federation, Ltd., and a past chairman of the Bristol Channel Ship Repairers' Association. Mr. Horace Willson was appointed senior vice-president. He is the chairman and managing director of William Hamilton and Co., Ltd., a director of the Fairfield Shipbuilding and Engineering Company, Ltd., David Rowan and Co., Ltd., and Charles Howson and Co., Ltd., and is also president of the Clyde Shipbuilders' Association. Mr. E. J. Hunter, a director of Swan, Hunter and Wigham Richardson, Ltd., and of the Wallsend Slipway and Engineering Company, Ltd., was elected the second vice-president, and Mr. George C. Parker, managing director of the Caledon Shipbuilding and Engineering Company, Ltd., was appointed to the office of third vice-president. The new chairman of the conference and works board is Mr. Henry Robb, chairman and managing director of Henry Robb, Ltd., and the vice-chairman of the board is Mr. Howard Johnson, who is the managing director of Hall Russell and Co., Ltd., a director of the Burntisland Shipbuilding Company, Ltd., and of Alexander Hall and Co., Ltd., and also president of the Scottish East Coast Shipbuilders' Association.

Miscellanea

MOBILE EXHIBITION.—We are informed by Newman Hender and Co., Ltd., Woodchester, Stroud, Glos, that it has fitted out a trailer as a mobile exhibition, which is now touring the country to show the various valves it makes.

CORRECTION.—On page 664 of our issue of November 12th, we inadvertently gave the name of the manufacturers of the brake-operating gear for mine cars as Distinction Engineering Company, Ltd., Workington, instead of Distington Engineering Company, Ltd.

PROTECTION OF STRUCTURAL STEEL.—A symposium on "The Protection of Structural Steel," organised by the corrosion group of the Society of Chemical Industry, will be held at the Institution of Civil Engineers on March 31 and April 1, 1955. The papers to be presented will include accounts of practical experience and of research with protective coatings gathered from France, Belgium, Holland, Sweden and the U.S.A., as well as Great Britain. Non-members of the corrosion group who wish to receive full details should apply to Mr. S. C. Britton, The Tin Research Institute, Fraser Road, Perivale, Greenford, Middlesex.

SPARK MACHINING EQUIPMENT DEMONSTRATION.—A demonstration of "Sparcatron" spark machining equipment and a selection of the other tool room and machine shop equipment handled by the firm is to be held by Burton, Griffiths and Co., Ltd., at its showrooms at 93, Albert Embankment, London, S.E.11, from November 22nd to December 4th next.

FIFTIETH ANNIVERSARY OF BRIXTON SCHOOL OF BUILDING.—The Brixton School of Building, which is one of the London County Council's educational establishments, has reached its fiftieth anniversary. The occasion is being celebrated by an exhibition, which is now open at the Building Centre, Store Street, London, and will be held until December 1st.

DIFFUSE REFLECTION GLASS.—A glass for instrument dial covers now being made by Pilkington Brothers, Ltd., has both surfaces lightly obscured to mitigate the nuisance caused by reflection without actually reducing the amount of light reflected. The glass is available in thicknesses 2·6mm and upwards, and at present in sizes up to 18in by 12in. It can be obtained toughened if required, and bent glass to approved curves is available as well as flat glass. This form of glass is stated to be particularly suitable for meter and gauge glasses where the observer is positioned at some distance from the instrument panels and is unable to move into a position to avoid reflections.

SINGLE-STACK PLUMBING FOR FLATS.—On November 10th Mr. William Deedes, Parliamentary Secretary to the Ministry of Housing and Local Government, opened an exhibition of single-stack plumbing at the Royal Sanitary Institute. He remarked on marked saving in cost achieved when building a block of flats with this system of plumbing incorporated in them, the cost per flat in a five-storey block being £20, as compared with £34 for the one-pipe system or £41 for the two-pipe system in the same block. The demonstration will be open until December 1st. Hourly transport is being provided from the Public Works Exhibition at Olympia to the Royal Sanitary Institute.

INSTITUTION OF CHEMICAL ENGINEERS EXAMINATIONS.—The Institution of Chemical Engineers has recently published new "Regulations for the Admission of Student, Graduate, and Corporate Members, and for the Examination of the Institution." These regulations contain the syllabuses for the examination which is to be held for the first time in 1956. The preliminary or Part I of the new examination will, however, also be held in 1955 immediately before the last examination in papers C, D, E and F of the present examination as described in the Institution's pamphlet, "Hints to Candidates." The closing date for entry to both the present and new examinations is June 1st in each year. Further particulars may be obtained from the Institution of Chemical Engineers, 56, Victoria Street, London, S.W.1.

RESEARCH AND INDUSTRIAL PRODUCTIVITY.—The Department of Scientific Industrial Research states that on Monday next, November 22nd, the Lord President of the Council will speak at a luncheon preceding a working conference on "Research and Industrial Productivity." The conference has been organised by the D.S.I.R., in association with the British Productivity Council and the British Institute of Management. It will be attended by leading industrialists, trade unionists and research directors, and the object is to discuss how research is helping to increase industrial productivity and what more can be done. The main subjects of discussion will be materials and fuel, costs and economics, work organisation and the place of the individual or group in the drive for increased productivity. The conference will be private but it is hoped that a report of the proceedings will be made available later.

MR. A. H. GINMAN.—We have learned with regret of the death, in Canada, on November 7th, of Mr. Albert Harry Ginman, a former president of the Canadian Marconi Company. He was seventy-nine. Mr. Ginman was born in England and at the age of eighteen he joined the Post Office staff as a telegraphist, subsequently transferring to the Cuba Submarine Telegraph Company, Ltd., which was later merged with Cable and Wireless, Ltd. At the age of twenty-seven he joined Marconi's Wireless Telegraph Company, Ltd., and worked with Marconi himself. He was transferred to the American Marconi Company in 1902. Seven years later, as manager of the wireless station at Siasconset, Mass., he directed the operations involved in the rescue of 760 passengers and crew from the liner "Republic," in collision in dense fog, and sinking. The successful rescue led to the compulsory adoption of wireless equipment in all large ships. In 1911 Mr. Ginman was appointed manager of the Pacific Coast division. After returning, in 1917, to the parent Marconi Company in England, he was shortly sent to the Far East, where for twelve years he acted as the company's general representative in China and Japan. During this period, among many other important undertakings, he played a leading part in the formation of the Chinese National Wireless Telegraph Company, Ltd., of which he became chairman. After returning to England in 1929, Mr. Ginman was appointed joint general manager of the Marconi Company, his promotion to general manager following in 1933. In 1935 Mr. Ginman relinquished this position to take up two appointments in Canada, the presidency of the Canadian Marconi Company and the post of general manager in Canada of Cable and Wireless, Ltd.

Personal and Business

MR. J. DEAN, secretary of A.P.V.-Paramount, Ltd, Crawley, Sussex, has been appointed a director of the company.

WESTLAND AIRCRAFT, Ltd., Yeovil, announces the appointment of Major J. W. Richardson as manager of its London office.

HOLDEN AND BROOKE, Ltd., Manchester, has moved its York office to 2, St. Sampson's Square, York (telephone, York 4583).

Q.V.F., Ltd., Stone, Staffs, has appointed Guest Industrials, Ltd., 81, Gracechurch Street, London, E.C.3, as selling agent in Yugoslavia.

MR. F. P. O. STRANGE has been appointed sales manager, and MR. C. D. Wenham, contracts manager, of Teddington Industrial Equipment, Ltd., Sunbury-on-Thames.

SIR GRAHAM HAYMAN, chairman of the management committee of the Distillers Company, Ltd., has been elected deputy president of the Federation of British Industries.

RHODES, BRYDON AND YOUATT, Ltd., Stockport, states that Mr. W. Latta, sales manager, has been appointed a director.

STANDARD TELEPHONES AND CABLES, Ltd., has moved its Leeds branch office and cable depot to 6–8, York Place, Leeds, 1 (telephone, Leeds 22900). Mr. L. Tillotson is the branch manager.

THE LOEWY ENGINEERING COMPANY, Ltd., has moved to Wallisdown Road, Bournemouth (telephone, Winton 5000). The company's London office continues at 376, Strand, W.C.2 (telephone, Temple Bar 9881).

WATTEN EMULSIFYING MACHINES, Ltd., states that it has appointed Charles E. Douglas and Co., Ltd., 86, Strand, London, W.C.2, as its sole representative for London, the Home Counties, and the North-West.

MR. H. J. STILES has been appointed sub-contracts manager of de Havilland Propellers, Ltd., Lostock. For the past two years he has been manager of de Havilland Engine Company's northern unit at Lostock.

THE UNIVERSITY OF LONDON has announced the appointment of Dr. James Dwyer McGee to the Chair of Instrument Technology at the Imperial College of Science and Technology. Dr. Nicol Gross has been appointed to the Readership in Production Engineering at the Imperial College.

F. C. ROBINSON AND PARTNERS, Ltd., states that its head office and sales and service departments will be moved on December 13th to 122, Seymour Grove, Old Trafford, Manchester, 16 (telephone, Chorlton 5366). The company's factory continues at Councillor Lane, Cheadle, Cheshire.

GLANMORFA, Ltd., Llanelly, states that for administrative reasons, its associated company, Thomas and Clement, Ltd., has been put into voluntary liquidation. The business of Thomas and Clement, Ltd., has been amalgamated with that of Glanmor Foundry Company, Ltd., and production at the Morfa Engineering Works, Llanelly, will remain unchanged with the same personnel.

MR. G. H. KENDALL, formerly an assistant chief engineer of the dyestuffs division of Imperial Chemical Industries, Ltd., has joined the board of Henry Hargreaves and Sons, Ltd., Bury, Lancs. Mr. Harry Hargreaves has been appointed chairman, and Mr. H. Gordon Hargreaves, managing director, of the company. Mrs. A. A. Currie, Mr. J. Bleakley and Mr. G. Murphy have been elected directors.

HEENAN AND FROUDE, Ltd., Worcester, has now acquired the balance of the issued capital of British Organic Products, Ltd., 7, Old Bailey, London, E.C.4. Mr. W. Bryan Draper, managing director of Industrial Waste Eliminators, Ltd., has been appointed to the board of British Organic Products, Ltd., the other directors being Mr. F. J. Fielding (chairman), Mr. A. C. Hayes and Mr. A. H. Langford. The company will be carried on as a wholly owned subsidiary of Heenan and Froude, Ltd.

Contracts

BRITISH INSULATED CALLENDER'S CONSTRUCTION COMPANY, Ltd., has received an order from British Railways for the supply and installation of overhead electrification equipment for an extension of the present Liverpool Street–Shenfield electric service as far as Chelmsford and Southend (Victoria), Essex. The contract is part of a £2,500,000 scheme, announced by British Railways last year, to institute through electric services from London to Chelmsford and Southend (Victoria) by linking these towns with the already existing service between Liverpool Street and Shenfield, which was completed in September, 1949. The extensions involve the electrification of a further 9¼ miles of route between Shenfield and Chelmsford and a further 21¼ miles between Shenfield and Southend (Victoria). It is hoped to complete the new electrification early in 1957 in time to relieve congestion on the London, Tilbury and Southend line, when the effects of the major civil engineering works necessary for electrification from Fenchurch Street to Southend Central begin to be felt. The overhead equipment will be generally similar to that installed on the section between Liverpool Street and Shenfield. It will operate at 1500V d.c., and, on the main track, will utilise a compound catenary system consisting of a hard-drawn copper strand as the main catenary, an auxiliary catenary supported by solid copper dropper wires and a grooved cadmium-copper contact wire suspended from the auxiliary catenary by loop droppers. The three wires will be jumpered together in every span and will provide a flexible system enabling trains to run at speeds of up to 70 m.p.h.

British Patent Specifications

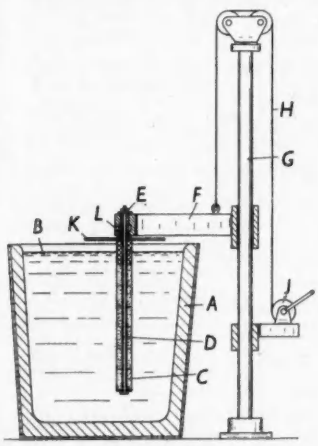
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

METALLURGY

716,856. November 26, 1952.—SUPPLYING SUBSTANCES TO A BATH OF MOLTEN METAL, A/S Bjolvefossen, Akersgatan 8, Oslo, Norway.

Referring to the drawing, a ladle *A* is filled with molten metal *B*, which may consist either of a pure metal or of an alloy. A number of briquettes *C*, prepared in accordance with the invention are supported on a wire or rod *D* and supported by means of a nut *E* on an arm *F*. The latter can be raised or lowered upon a vertical column *G* by means of a steel wire *H* and a hoisting gear *J*. The column may be rotatably supported, so that the arm *F*. In this manner it is possible to join together briquettes of different materials, whereby different reactions are obtainable. One or more of the topmost briquettes consist of refractory material. In this manner the



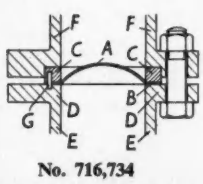
No. 716,856

rod may be protected in the slag zone. Above the bath of molten metal, a disc *K* may be provided to prevent sputter. In the arm *F*, an outlet *L* may be provided for gas evolved by the briquettes and flowing upwards through the central aperture. The invention may also be used in connection with a melting furnace or in a suitable cavity in a tap runner extending from a melting furnace and with high-frequency furnaces, and for desulphurisation of pig iron flowing from blast-furnaces.—*October* 13, 1954.

SAFETY DEVICES

716,734. February 8, 1952.—SAFETY DEVICES FOR PRESSURE VESSELS, The Distillers Company, Ltd., 12, Torphichen Street, Edinburgh, 3, Scotland. (*Inventor: Thomas Bruce Philip.*)

The invention relates to safety devices for pressure vessels of the type providing an escape path for fluid within the vessel, the path being normally closed by means of a dome-shaped diaphragm which ruptures under the influence of fluid pressures within the vessel in excess of a specified pressure. The drawing shows a vertical section of a safety device in which the frangible diaphragm *A*, with an annular flange *B*, is held in position within the safety device by the clamping ring *C* against the body of the safety device *D*. *E* represents the part of the safety device escape pipe directly connected to the pressure vessel, and *F* is the escape pipe open to the atmosphere. *G* is a peg fixed in the lower portion of the body of the safety device, which supports the lower side of the diaphragm. The annular flange of the diaphragm and the clamping ring bear corresponding holes which fit over the peg, thus making up the interrelated mating means according to the invention. Modified arrangements of diaphragms are also shown in the specification.—*October* 13, 1954.



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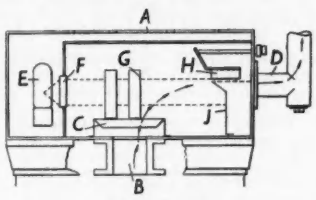
TESTING INSTRUMENTS AND APPARATUS

716,654. April 28, 1952.—SMOKE-DETECTING SYSTEMS, The Walter Kidde Company, Ltd., Lux Works, Belvue Road, Northolt, Middlesex. (*Inventor: Cyril Clifford Hall.*)

The invention relates to apparatus for use in smoke-detecting systems, in which sample air is drawn through a smoke-detecting unit and energises an audible alarm indicator, the detecting unit comprising a chamber containing a light source and screened photo-electric cells illuminated by light scattered from the smoke particles in the sample air. As shown in the drawing, the detecting unit comprises a light-proof casing *A* having an inlet *B* for sample air, which is screened by a baffle *C* in the bottom of the casing and an air outlet *D* in the end of the casing *A*. A light source *E* is mounted in a separate compartment at one end of the casing *A* and is associated with a condenser lens system *F* to project a substantially parallel beam of light towards the sample air outlet *D*, as shown in chain lines in the drawing. A group of five photo-electric cells built up on a pentagonal framework *G* and facing inwards, surround the light beam, but are masked to prevent direct illumination from the light source *E*. A single photo-electric cell *H* is positioned near the air sample outlet and is arranged so that its lower surface lies



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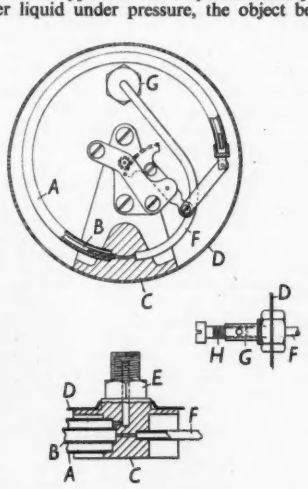
at or near the top edge of the parallel light beam. This cell *H* may be partially masked by a vertically adjustable mask or may be vertically movable, and is connected in one arm of a bridge circuit, in which the other five photo-electric cells mounted on the framework *G* are arranged in another arm. By suitable adjustment of the mask or of the position of the cell itself the potential of the single photo-electric cell *H* may be made to balance the bridge circuit. The special feature of the present invention resides in the provision of a screen *J* nearly up to the plane of the bottom surface of the single electric cell *H*, so that only a narrow slot of light from the main beam passes under the single cell, as shown in the drawing.

In the construction shown, in which a narrow slot of light only is allowed to pass into the area under the single photo-electric cell *H*, the effect of the presence of smoke is to decrease the illumination of the single cell rather than to increase it, because the intensity of the direct beam falling on the cell is reduced and the amount of light dispersed from smoke particles lying in the path of the narrow slot of light passing under the cell is quite small. The amount of smoke particles, therefore, that need be present to give rise to an out-of-balance condition sufficient to actuate the audible alarm, is decreased. Thus the effect of introducing the screen is to make the known smoke-detecting unit more sensitive.—*October* 13, 1954.

716,996. March 24, 1952.—BOURDON TUBE LIQUID PRESSURE GAUGES, David Harcourt, Ltd., Linkula Works, 917–927, Coventry Road, Birmingham, 10. (*Inventor: Alfred John Mann.*)

The invention relates to pressure gauges of the Bourdon tube type for use in systems conveying oil or other liquid under pressure, the object being to



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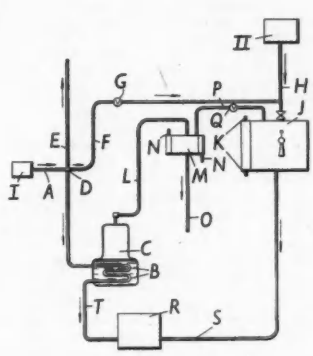
enable the tube of such a gauge to be filled with oil or other liquid in a more convenient manner. Referring to the drawing, there is contained in the main tube *A* a thin-walled tube *B* corresponding in shape to the main tube and of such flexibility that it has no appreciable effect on the normal action of the main tube. The inner tube extends along the whole or greater part of the length of the main tube. The fixed end of the main tube *A* is attached to a metal block *C* in the casing *D* of the gauge, and on this block is formed a pipe connection *E*, through which is supplied to the gauge the liquid whose pressure is to be measured. To the same block *C* is also attached one end of the inner tube *B* and also one end of an additional tube *F* serving as an extension of the inner tube. The other end of the tube *F* is attached to a vent fitting *G* on the rear of the gauge casing. Alternatively the tube *F* may be formed by an integral extension of the tube *B*. Filling of the main tube with oil or other liquid is effected by admitting the liquid at the pipe connection *E*. The liquid flows along the space between the two tubes *A* and *B* and thence along the inner tube *B* and the extension tube *F* to the vent *G*. After the tubes have been so filled the vent is closed by a sealing plug *H*. By the invention filling of the main tube with oil or other liquid and subsequent replenishment when necessary is claimed to be effected in a very simple and convenient manner.—*October* 20, 1954.

MISCELLANEOUS

716,603. July 5, 1950.—CONVERTING SEA WATER TO FRESH WATER BY EVAPORATION, David Rowan and Co., Ltd., 231, Elliot Street, Glasgow, C.3. (*Inventor: Ewen Henry Smith.*)

The invention relates to a method of and means for converting sea water to fresh water by steam supplied from auxiliary engines for marine practice.

Referring to the drawing, auxiliary engines are arranged in two groups, I and II. The first group, comprising those regularly in use when steam is being raised in a boiler exhausting at the lowest practicable pressure for vapour raising in the evaporator, and the second group, comprising auxiliaries operating intermittently. The first group of auxiliary engines feed an exhaust steam pipe *A* which, in turn, feeds the heating coils *B* of an evaporator *C* through a pipe branching from the



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pipe *A* at the branch connection *D*. From this connection also extend two pipes *E* and *F*, pipe *E* leading to the feed supply to the boilers and pipe *F* being fitted with a valve *G* to maintain a steady back pressure in the exhaust of the auxiliary engines I and leading surplus steam to the entry pipe *H* of a vacuum condenser *J*. This entry pipe is fed with exhaust steam from the second group of auxiliary engines II and leads to the vacuum condenser, a steam jet air ejector serving to create a vacuum in the condenser, which is cooled by sea water circulating through pipes *K*. Vapour from the evaporator *C* is led by a pipe *L* to a heat exchanger *M*, cooled, in like manner to the vacuum condenser *J*, by pipes *N*, and the condensate is drained off through a pipe *O* to a storage tank. The heat exchanger *M* and condenser *J* are elevated so that their condensates may drain off by gravity and they are interconnected by a pipe *P* fitted with a vacuum-retaining valve *Q*, which allows the vacuum to be communicated from the vacuum condenser to the heat exchanger and to the vapour space of the evaporator. The vacuum condenser and the heating coils of the evaporator communicate with a boiler feed water tank *R* through pipes *S* and *T* respectively. In operation of the apparatus sea water is fed to the evaporator *C* and exhaust steam from the first group of auxiliary engines is passed through the coils *B*. Water vapour is formed and is led by pipe *L* to the heat exchanger *M*, where it is condensed and drained off as fresh water. Also, exhaust steam from the auxiliary engines II, together with surplus steam from the pipe *F*, creates a vacuum in the condenser *J*, the vacuum being communicated by pipe *P* to the heat exchanger *M*, and thence by pipe *L* to the vapour space of the evaporator *C*. The vacuum assists formation of water vapour in the vapour space of the evaporator *D*, and so ensures greater efficiency of the apparatus.—*October* 13, 1954.

Launches and Trial Trips

KINGSTON TURQUOISE, trawler; built by Cook, Welton and Gemmell, Ltd., for the Kingston Steam Trawling Company, Ltd.; length 189ft, breadth moulded 32ft, depth moulded 17ft 6in, gross tonnage about 800, fish room 16,940 cubic feet; two 15kW steam-driven and one 10kW diesel-driven generators; one triple-expansion steam engine, by Charles D. Holmes and Co., Ltd., cylinder diameters 16½in, 28½in, 47in by 30in stroke, steam supplied at 225 lb per square inch by one multitubular boiler. Launch, October 15th.

BLACK PRINCE, cargo liner; built by the Burntisland Shipbuilding Company, Ltd., for the Prince Line, Ltd.; length between perpendiculars 345ft, breadth 52ft 7in, depth moulded to shelter deck 32ft 4in, deadweight 4900 tons, draught loaded 21ft 9¾in; twelve passengers; four holds, ten 5-ton, two 10-ton and one 25-ton derricks, steam deck machinery; Hawthorn-Doxford oil engine, four cylinders, 600mm diameter by 2320mm combined stroke, 3300 b.h.p., heavy fuel oil, two multitubular boilers. Launch, October 15th.

MARINIA, tug; built by Cook, Welton and Gemmell, Ltd., for the Overseas Towage and Salvage Company, Ltd.; length registered 120ft 9in, breadth moulded 28ft 6in, depth moulded 13ft 9in; electric deck machinery, two 60kW and one 15kW diesel-driven generators; British Polar Mark M46M diesel engine, 960 b.h.p. at 250 r.p.m. Launch, October 16th.

BEECHMORE, cargo liner; built by The Burntisland Shipbuilding Company, Ltd., for Johnson Warren Lines, Ltd.; length between perpendiculars 345ft, breadth 52ft 7in, depth moulded to shelter deck 32ft 4in, deadweight 4900 tons, draught loaded 21ft 9¾in; twelve passengers; four holds and a deep tank, ten 5-ton, two 10-ton and one 25-ton derricks, steam deck machinery; Hawthorn-Doxford opposed piston oil engine, four cylinders, 600mm diameter by 2320mm combined stroke, heavy fuel oil, 3300 b.h.p.—Trial, October 21st.

JAMES ROWAN, self-trimming collier; built by Hall, Russell and Co., Ltd., for the British Electricity Authority; length overall 340ft, length between perpendiculars 323ft, breadth moulded 43ft 3in, depth moulded 20ft 3in/25ft 9in, deadweight 3700 tons, draught loaded 18ft; four holds, steam deck machinery; "North Eastern Reheat" direct-acting, triple expansion steam engine, 1475 i.h.p., steam supplied at 220 lb per square inch by two oil-fired cylindrical boilers.—Launch, October 26th.

LONDON INTEGRITY, oil tanker; built by the Furness Shipbuilding Company, Ltd., for London and Overseas Freighters, Ltd.; length overall 556ft 5in, length between perpendiculars 525ft, breadth moulded 71ft, depth moulded 39ft 3in, deadweight 18,000 tons on 30ft 5¾in summer draught, trial speed 15 knots; twenty-seven cargo oil tanks, two pump rooms, four 500 tons per hour cargo oil pumps, two 150 tons per hour stripping pumps, steam deck machinery, two 60kW steam-driven generators; N.E.M.-Doxford, single-acting, two stroke, oil engine, six cylinders, 670mm diameter by 2320mm combined stroke, 6800 b.h.p. at 119 r.p.m., two Scotch boilers.—Launch, October 28th.

CERINTHUS, oil tanker; built at the Belfast shipyard of Harland and Wolff, Ltd., for the Hadley Shipping Company, Ltd.; length between perpendiculars 530ft, breadth moulded 69ft 3in, depth moulded 39ft; thirty-three cargo oil tanks, one main cargo pump room, two 550kW turbine-driven alternators, one 200kW diesel-driven alternator; one set of double reduction geared turbines, 7500 s.h.p., steam supplied at 500 lb per square inch and 800 deg. Fah. by two Babcock and Wilcox water-tube boilers. Trial, November 9th.

ZEALAND, cargo ship; built by Henry Robb, Ltd., for the Currie Line, Ltd.; length between perpendiculars 270ft, breadth moulded 45ft, depth moulded to upper deck 25ft 6in, deadweight 1850 tons on 17ft 3in mean draught, service speed 13 knots; twelve passengers; four holds, three of which are insulated, electric deck machinery, three 230kW diesel-driven generators; two British Polar seven-cylinder, two stroke, unidirectional diesel engines, total power 2620 b.h.p. at 300 r.p.m. drive a single propeller at 125 r.p.m. through two Barclay Curle "Vulcan" hydraulic couplings and a M.W.D. reverse reduction gearbox.—Launch, November 10th.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH INSTITUTION OF RADIO ENGINEERS

Tues., Nov. 30th.—N.W. SECTION: Reynolds' Hall, College of Technology, Sackville Street, Manchester, "Electronics and the Wind Tunnel," G. J. Scoles, 7 p.m.

Thurs., Dec. 2nd.—MERSEYSIDE SECTION: College of Technology, Byron Street, Liverpool, 3, "Electronics in Materials Handling," L. Landon Goodman, 7 p.m.——SCOTTISH SECTION: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Some Interesting Applications of Electronics to Photography," D. M. Neale, 7 p.m.

ENGINEERS' GUILD

Thurs., Dec. 2nd.—ORDINARY MEETING: Caxton Hall, Caxton Street, Westminster, London, S.W.1, "The Profession of the Land," P. H. White, 6 p.m.

HULL CHEMICAL AND ENGINEERING SOCIETY

Tues., Nov. 23rd.—Church Institute, Hull, "Synthetic Rubbers," F. A. Jones, 7.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Nov. 22nd.—LEEDS CENTRE: E.L.M.A. Lighting Service Bureau, 24, Aire Street, Leeds, 1, "New Lamps, New Uses and New Lighting Techniques," R. V. Mills, 6.15 p.m.——LEICESTER CENTRE: Demonstration Theatre of the East Midlands Electricity Board, Charles Street, Leicester, "The History and Development of Lighting," L. H. Hubble, 6 p.m.

Tues., Nov. 23rd.—Lighting Service Bureau, 2, Savoy Hill, London, W.C.2, "Light and Crime Detection," C. H. Edlin, 6 p.m.

Thurs., Nov. 25th.—BIRMINGHAM CENTRE: Regent House, St. Phillip's Place, Colmore Row, Birmingham, "Genology," F. Heasling, 6 p.m.

Fri., Nov. 26th.—BATH AND BRISTOL CENTRE: S.W. Electricity Board, Lecture Theatre, Old Bridge Street, Bath, "Lighting for Enjoyment," T. O. Freeth, 7 p.m.

Mon., Nov. 29th.—LEEDS CENTRE: Lecture Theatre, Yorkshire Electricity Board, Ferensway, Hull, Four short papers on Industrial Lighting, by Members of the Centre, 7.30 p.m.

INCORPORATED PLANT ENGINEERS

Thurs., Nov. 25th.—SHEFFIELD AND DISTRICT BRANCH: Grand Hotel, Sheffield, "Compressed Air in Industry," 7.30 p.m.

Fri., Nov. 26th.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, "Laundries," G. N. Freck, 7.30 p.m.

Mon., Nov. 29th.—W. AND E. YORKSHIRE BRANCH: The University, Leeds, "Fuel Injection Equipment for High-Speed Oil Engines," W. H. Simpson, 7.30 p.m.

INSTITUTE OF FUEL

Thurs., Nov. 25th.—Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, "Peat-Fired Power Stations," W. Cronin and J. F. Lang, 5.30 p.m.

INSTITUTE OF INDUSTRIAL SUPERVISORS

Thurs., Nov. 25th.—LONDON N.W. SECTION: Technical College, Harrow, "Safety—A Challenge to the Supervisors," 7.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Thurs., Nov. 25th.—N.E. COAST SECTION: Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "Automatic Boiler Controls," Lt. Young, 6.15 p.m.

Fri., Nov. 26th.—MERSEYSIDE AND N.W. SECTION JUNIOR LECTURE: Technical College, Barrow-in-Furness, "Air Conditioning of Ships," J. K. W. Macvicar, 7.30 p.m.

INSTITUTE OF METALS

Thurs. and Fri., Nov. 25th and 26th.—4, Grosvenor Gardens, London, S.W.1, Meeting for the benefit of Members unable to take part in the Autumn Meeting in Switzerland. Thurs., 2.30 p.m., Discussion on "The Constitution of Titanium Alloys"; Fri., 10 a.m., Discussion on "Preferred Orientation"; Fri., 2.30 p.m., Discussion on "Corrosion and Staining of Aluminium Alloys."

Thurs., Nov. 25th.—BIRMINGHAM LOCAL SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "The Working of Metals," J. G. Wistreich, 6.30 p.m.

INSTITUTE OF NAVIGATION

To-day, Nov. 19th.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, Discussion on "The Cause of Radar-Assisted Collisions," F. J. Wylie, 5 p.m.

INSTITUTE OF PHYSICS

Tues., Nov. 23rd.—NON-DESTRUCTIVE TESTING GROUP: Lecture Theatre, New Horticultural Hall, Vincent Square, London, S.W.1, Discussion on "The Fundamentals of Radiographic Definition, Resolution and Unsharpness," opened by R. Halmshaw and G. Spiegler, 2 p.m.

INSTITUTE OF REFRIGERATION

Thurs., Nov. 25th.—Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, "The Use of Heat Pumps of Small Capacity for Various Purposes in Great Britain," M. V. Griffith, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Tues., Nov. 23rd.—N.E. ENG. GROUP: Whinney Hill Secondary School, Durham City, "Brains Trust," 7 p.m.——WESTERN CENTRE: Rougemont Hotel, Exeter, "Thin Wall Bearings," P. T. Holligan, 7.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Thurs., Nov. 25th.—MANCHESTER CENTRE GRADUATES' AND STUDENTS' SECTION: Reynolds' Hall, College of Technology, Sackville Street, Manchester, "Electro-Precipitators," D. O. Heinrich, 6.45 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Nov. 23rd.—RAILWAY MEETING: Great George Street, Westminster, London, S.W.1, "Standardisation of Type and Design Applied to Steam Locomotive Shed Roofs," V. F. Beer; "Smoke Extraction from Engine Sheds: An Account of Some Full-Scale Tests," R. L. McIlmoyle and D. W. Peacock, 5.30 p.m.——N.W. ASSOCIATION: Engineers' Club, Albert Square, Manchester, Students' Meeting—a Discussion on "The First Years of Professional Employment," 6.30 p.m.

Tues., Nov. 30th.—ROAD MEETING: Great George Street, Westminster, London, S.W.1, "Prestressed Units for Short-Span Highway Bridges," A. D. Holland, 5.30 p.m.

Wed., Dec. 1st.—MIDLANDS ASSOCIATION: Midland Institute, Birmingham, "Nuclear Reactors and Power Production," Sir Christopher Hinton, 6 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Nov. 22nd.—RADIO SECTION: Savoy Place, London, W.C.2, Informal Lecture on "Plastics for the Radio Engineer," 5.50 p.m.

Tues., Nov. 23rd.—MEASUREMENTS SECTION: Savoy Place, London, W.C.2, "The Application of the Hall Effect in a Semi-Conductor to the Measurement of Power in an Electromagnetic Field," H. E. M. Barlow; "Audio-Frequency Power Measurements by Dynamometer Wattmeters," A. H. M. Arnold, 5.30 p.m.——N. MIDLAND CENTRE: British Electricity Authority, 1, Whitehall Road, Leeds, 1, "Electric Lifts in Post-War Housing," C. G. L. Morley, 6.30 p.m.——LONDON STUDENTS' SECTION: Savoy Place, London, W.C.2, "Attitudes of Mind," A. R. Cooper, 6.30 p.m.

Wed., Nov. 24th.—SUPPLY SECTION: Savoy Place, London, W.C.2, "Supervisory Equipment for the Indication of Shaft Distortion in Steam Turbines," D. Antrich, H. W. B. Gardiner and R. K. Hilton, "The Electrical Measurement of Steam Turbine Rotor Movements, with Special Reference to the Operation and Design of Modern Power Plant," J. L. Ashworth, J. S. Hall and A. H. Gray, 5.30 p.m.

Tues., Nov. 30th.—MEASUREMENTS SECTION: Savoy Place, London, W.C.2, Discussion on "The Servicing of Electronic Measuring Instruments and its Effect on Their Design," opened by Denis Taylor, 5.30 p.m.——LONDON STUDENTS' SECTION: R.E.M.E. Training Centre, Hazebrouck Barracks, Arborfield, Berks, Film Evening, 7 p.m.

INSTITUTION OF ENGINEERING INSPECTION

Tues., Nov. 30th.—COVENTRY BRANCH: Room A5, Technical College, Coventry, "Recent Developments in Metrology, with Special Reference to Interferometry," W. Foster, 7.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Nov. 30th.—39, Elmbank Crescent, Glasgow, "Components of the Propulsive Efficiency of Screw Vessels," G. Johnson, 7.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Nov. 19th.—GENERAL MEETING: 1, Birdcage Walk, Westminster, London, S.W.1, James Clayton Lecture, "Guided Missiles," G. W. H. Gardner, 5.30 p.m.

Tues., Nov. 23rd.—BIRMINGHAM A.D. CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham, "Tyre Characteristics as Applicable to Vehicle Stability Problems," T. J. P. Joy and D. C. Hartley, 6.45 p.m.——WESTERN A.D. CENTRE: Royal Hotel, Bristol, "Engine Research and Development as a Service to Industry," J. H. Pitchford, 6.45 p.m.

Wed., Nov. 24th.—AUTOMOBILE DIVISION: 1, Birdcage Walk, Westminster, London, S.W.1, "Transmissions for Small European Cars," 6.45 p.m.——SCOTTISH BRANCH: Royal Technical College, George Street, Glasgow, Presidential Address, R. W. Bailey, 7.30 p.m.——SOUTHERN BRANCH: Cornwall Hall, The Drive, Sevenoaks, Kent, "Nuclear Reactors and Power Production," Sir Christopher Hinton (Read by J. M. Kay), 7 p.m.——SOUTHERN GRADUATES' SECTION: Technical College, Brighton, "Varied Aspects of American Machine Tool Industry," J. Holden, 7 p.m.——WESTERN GRADUATES' SECTION: Pump Room, Bath, "Crane Erection Management," B. E. Walsh, 7.15 p.m.

Thurs., Nov. 25th.—N.W. BRANCH: Grosvenor Hotel, Chester, "Some Problems in Lubrication and the Substances Called Additives," A. Towle, 7.15 p.m.

Fri., Nov. 26th.—GENERAL MEETING arranged in conjunction with the APPLIED MECHANICS' GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, "Dynamic Stresses in Electric Overhead Travelling Cranes Due to the Hoisting and Lowering of Loads," E. Lightfoot and B. L. Clarkson, 5.30 p.m.

Tues., Nov. 30th.—STEAM GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, "Planning and Operation of Maintenance Schedules for Steam Power Plants," 6.45 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Wed., Nov. 24th.—INFORMAL MEETING: Conference Room, 4th Floor, Waterloo Bridge House, London, S.E.1, "Some Personal Views on the Mechanisation of Auto Exchange Maintenance," F. H. Horner and B. H. E. Rogers, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, Nov. 19th.—W. WALES SECTION: Central Library, Alexandra Road, Swansea, "Designing for Production," C. L. Boult, 7.30 p.m.

Mon., Nov. 22nd.—SHEFFIELD GRADUATE SECTION: Royal Victoria Station Hotel, Sheffield, "The Factory Inspector and the Production Engineer," D. E. Jones, 6.30 p.m.

Wed., Nov. 24th.—SHREWSBURY SECTION: Technical College, Shrewsbury, "Patents and Registerings Design," S. J. Parker; "Human Safety in Engineering," B. G. Williams, 7.30 p.m.——WOLVERHAMPTON GRADUATE SECTION: Technical College, Wulfruna Street, Wolverhampton, "Some Impressions of a Visit to America with a Productivity Team," W. F. Garnham, 7.30 p.m.

Tues., Nov. 30th.—LUTON SECTION: Pink Room, W. H. Allen Sons and Co., Ltd., Bedford, "Noise and Vibration in Machinery," A. J. King, 7.15 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., Nov. 22nd.—MANCHESTER BRANCH: Engineers' Club, Albert Square, Manchester, "Modern Practical Safety Precautions in the Rubber Industry," E. Morris, 6.15 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Thurs., Nov. 25th.—11, Upper Belgrave Street, London, S.W.1, "The Design and Construction of the Nuclear Reactor Buildings at Windscale Works, Sellafield," D. R. R. Dick, 6 p.m.

Fri., Nov. 26th.—MIDLAND COUNTIES BRANCH: James Watt Memorial Institute, Great Charles Street, Birmingham, "Structural Use of Timber," S. Woolf, 6 p.m.

Mon., Nov. 29th.—LANCASHIRE AND CHESHIRE BRANCH: Reynolds' Hall, College of Technology, Manchester, "The Design Features and Collapse Investigation of the Tacoma Narrows Bridge," S. M. Copper, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Nov. 19th.—Pepys House, 14, Rochester Row, London, S.W.1, Chairman's Address, "Engineering Plant in Buildings," S. G. Clark, 7 p.m.

Mon., Nov. 22nd.—N.W. SECTION: Engineers' Club, Albert Square, Manchester, "Braking Practice," C. R. Gundersen, 7.30 p.m.

LIVERPOOL ENGINEERING SOCIETY

Wed., Nov. 24th.—24, Dale Street, Liverpool, "Vacuum Concrete," J. N. Gooch, 6 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

Fri., Nov. 26th.—Engineers' Club, Albert Square, Manchester, "Submarine Telegraph and Telephone Cables," F. Mattingley, 6.45 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Nov. 26th.—Mining Institute, Newcastle upon Tyne, "The Use of a Digital Computer with Particular Reference to the Analysis of Structures," R. K. Livesley, 6.15 p.m.

ROYAL AERONAUTICAL SOCIETY

Thurs., Nov. 25th.—SECTION LECTURE: 4, Hamilton Place, London, W.1, "The Development and Investigation of Fatigue Cracks," N. Thompson, 7 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., Nov. 22nd.—GENERAL MEETING: 12, Great George Street, London, S.W.1, Discussion on "The Building Surveyors' Contribution in Private Practice and the Public Service," opened by Cyril H. Walker, 5.30 p.m.

SHEFFIELD SOCIETY OF ENGINEERS AND METALLURGISTS

Wed., Nov. 24th.—Mappin Hall, Sheffield, "High Temperature Water Cooling of Open-Hearth Furnaces by Means of Steam-Producing Elements," F. J. Feltoe and P. M. Moreton; "The Cooling of Large Rolling Mill Drives," P. M. Moreton, 6.30 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

To-day, Nov. 19th.—39, Elmbank Crescent, Glasgow, "Direct-Reading Spectrography with Special Reference to the Analysis of Ferrous Metals with the Quantometer," A. Argyle, 6.45 p.m.

WOMEN'S ENGINEERING SOCIETY

Tues., Nov. 30th.—MANCHESTER BRANCH: Gas Theatre, Town Hall, Manchester, "The Manufacture of Fashion Jewellery and Accessories," Miss D. Pile, 7 p.m.